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Journal

of the

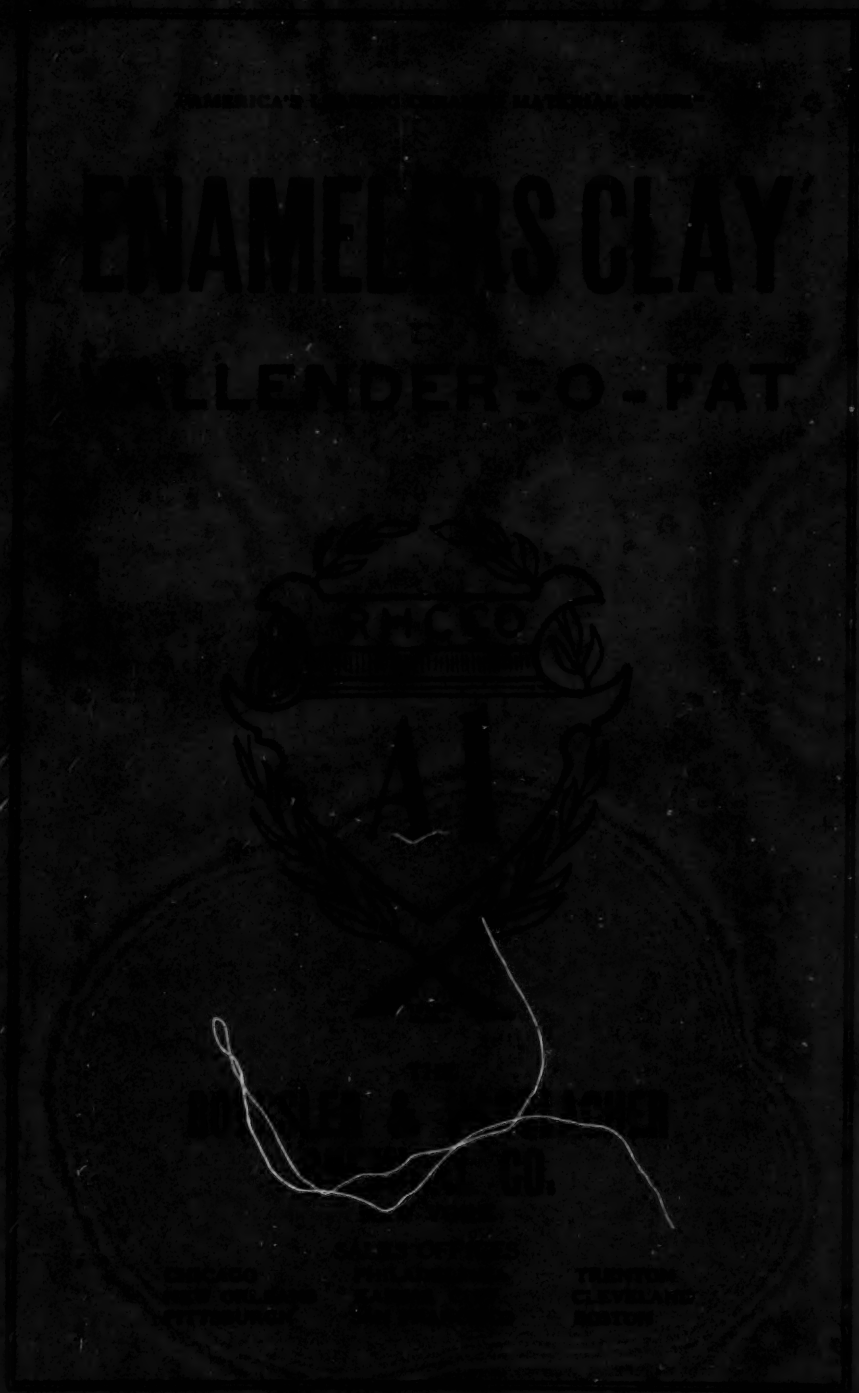
American Ceramic Society

Ceramic Abstracts and The Bulletin

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

CONTENTS

	Page
Original Papers:	
Mechanism of Plasticity from Colloid Standpoint—Bole	469
A New Type of Gas-fired Vitreous Enameling Furnace—Clark	478
Some Properties of Zinc Oxide Bodies—Libman	488
The Harrop Tunnel Kiln—Cramer	493
The Control of Glaze-fit by Means of Tensile Test Specimens—Riddle and Laird	500
Disintegration of Soda Lime Glasses in Water—Williams	504
Notes on Shivering of Terra Cotta—Carruthers	518
Porosity: VII. The Determination of the Porosity of Highly Vitrified Bodies—Washburn and Bunting	527
Soluble Salts and Clay Wares—Parmelee	538
Need for More Refractory Heat Insulators—Pike	554
Ceramic Abstracts	193
The Bulletin:	
Editorials	117
The Evolution and Development of Glass House Equipment—Herzog	124
Kiln Manipulation in Relation to School and Studio Pottery—Rhead	131
Colloquium on Feldspar and Feldspar Grinding	133
Discussion on "Derry Feldspar Quarry"	146
Theory of Plasticity and Possible Commercial Application	147
Note on the Relation of the Structure of Clay Grains to the Plasticity of Clays—Schurecht	153
Discussions on "New Developments in Oxy-chloride Stucco and Flooring"	155
Discussion on "Fire Clays of the Eastern Coalfield of Kentucky"	161
Discussion on "Microscopic Study of Ground Coat and Cover Coat Enamel Reactions"	161
Activities of the Society	163
Notes and News	165



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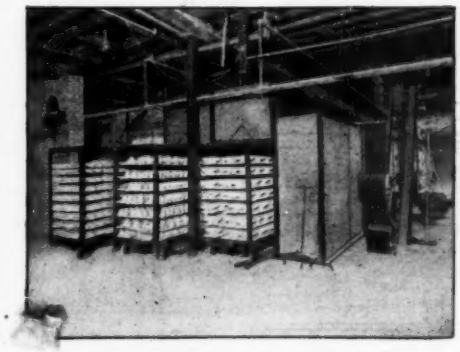

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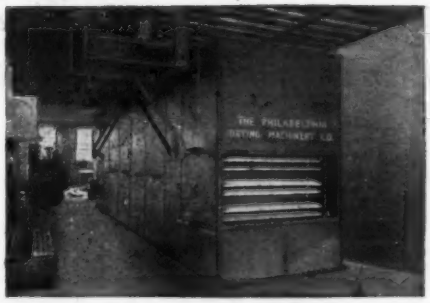

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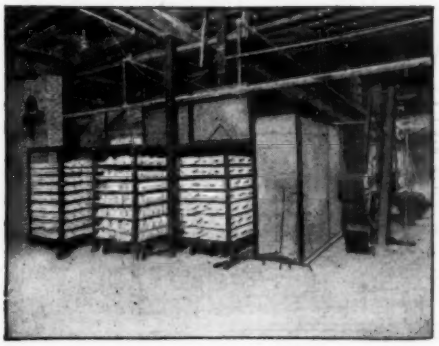

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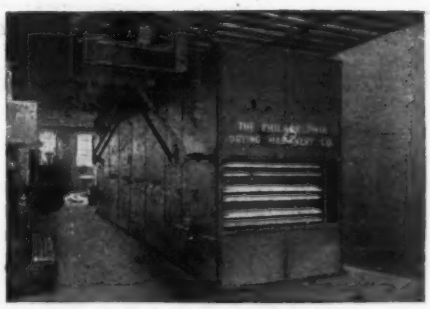

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ORIGINAL PAPERS

MECHANISM OF PLASTICITY FROM COLLOID STANDPOINT[1]

BY G. A. BOLE[2]

ABSTRACT

Introduction.—Brief statement of present conceptions of the colloid chemists.

Theory.—Plasticity is caused by the enveloping film of colloidal material which surrounds the clay grains, this film being of opposite polarity to the grain proper. Addition of electrolyte acting as deflocculant causes outer layer of film to be attracted to ion of same polarity as clay particle, thus reducing effective diameter and increasing polarity of plasticity inducing particles. Particles which were held by surface forces of "particles in contact" are no longer in contact and are actually repelling each other due to like and increased polarity. A flocculating ion drives action in opposite direction causing an increase in depth of colloid film thereby increasing surface in actual contact and decreasing repulsive force of plasticity inducing particles. Transport numbers as well as polarity are governing factors in ions of electrolytes.

Measurements.—Touch method is proven to be unreliable. Desirability of a unit of measurement. Plea for a unit of colloidality and standard method for measurement.

Introduction

Matter in the colloidal state means simply that any species of matter, if sufficiently subdivided, becomes colloidal. Whether it be a gel or suspension depends on its state of subdivision or dispersion. Any kind of matter may, theoretically at least, appear in the form of a jelly. We will use the term "gel" to indicate an agglomerated sol. The term "gel" is meant to include a jelly but is in no way synonymous with it. Ceramists prefer the terms "flocculated" and "deflocculated" to indicate that a clay is in the "gel" or "sol" state, respectively. We shall use the term "colloid" to

[1] Published with the permission of the Director of the U. S. Bureau of Mines.

[2] This presentation is the written form of a talk given before the annual meeting of the American Ceramic Society.

indicate those particles with a diameter of 0.0005 mm. to 0.000005 mm.; these limits are of course somewhat elastic. The prime requisite to colloidality, with a few exceptions which do not concern us, is that the material in question be highly insoluble in the suspending medium, such as clay in water.

The colloids in clay are very largely at least crystalline in nature. The X-ray spectra we hope will tell us shortly just to what extent this is true.

Since the colloidal state of matter is a case of subdivision, we could call it the state of large surfaces; *i. e.*, as we subdivide an object, its surface becomes larger in comparison with its mass. So, for a given quantity of material in the colloidal state, we have relatively enormous surface areas. So any phenomena with relation to the surface will be greatly multiplied as we approach and proceed through the colloidal state of subdivision. Some of these phenomena are: surface tension (interface forces); cohesion (as a mass); adhesion; adsorption, etc.

We may then further define the colloidal state as the state of augmented surface phenomena.

The factor which interests us most just now is adsorption; it is a property that every surface has, and for a given substance varies directly as the surface area. Since adsorption is a selective phenomenon, all substances are not adsorbed to the same extent upon a given surface. The minerals which go to make up a clay adsorb electrolytes very strongly and to a lesser degree some colloids; always remembering that these minerals themselves comprise, for the most part at least, the colloid as well as the larger agglomerates.

Since a clay consists of a collection of particles with diameters ranging all the way from that of simple molecules (adsorbed salts) to that of particles plainly visible under the low power microscope, we may ask what proportion of this collection is of colloidal dimensions. Recent work would seem to point to their being roughly in the neighborhood of 10 to 40 per cent in the clays examined.

No matter what our views may be as to the mechanics of plasticity and its measurement, I believe we can agree that it is summed up in the internal forces which resist the free passage of clay particles (macroscopic, microscopic, or submicroscopic) over each other.

If the force of gravity is sufficient to overcome this friction, we call the motion induced, viscous flow; if a force greater than gravity is required to overcome the frictional resistance, we call it plastic flow, and the force required, the yield value. Since this friction between the particles takes place only at the surface of the particle, it is very evident that it will be greater the greater the contact surface area. In other words, the nearer the individual particles approach colloidal dimensions, the greater the yield value, or the greater the plasticity factor.

The fact that an electrolyte may first cause a slip to decrease in viscosity, then increase, and again slowly to decrease as progressive concentrations of electrolyte are used, is explained by one authority as being due, first, to deflocculation of the particles, second, to the "salting out" effect as illustrated by soaps and the third stage as a dehydration or squeezing out of water from the already flocculated agglomerates.

Theory

I like to think of the mechanics of the clay water system as follows: Let us mentally picture the vertical cross section of a hypothetical clay suspension—particles with their adsorbed films. The particles themselves may be either microscopic or sub-microscopic and the adsorbed film of submicroscopic material either amorphous or crystalline—it makes no difference. The system is, let us say, a clay cream just too thick to flow without addition of an electrolyte.

The clay particles have the power of adsorbing strongly on their surfaces these other particles, due to their surface energy (probably of a negative electrical character), the surface film being of positive polarity as regards the adsorbing particle. This film is in effect a dielectric and the clay particles, together with their adsorbed films, are in effect neutral bodies which are subject to the laws of attraction and repulsion. This constitutes a part of the frictional force that is required to be overcome, and is included in the yield value. If the particle is small enough to possess a Brownian movement of sufficient amplitude it will stay in suspension, and if not it will slowly settle in accordance with Stokes' law. We have then, in the case of the larger particles including their adsorbed films, in effect two electrically neutral bodies in contact. The force with which the outer layers of this film is held varies inversely as its thickness. So, as we apply a force of given magnitude, it will at first cause it to slip. The very slight elasticity shown by a clay in passing from a die may be caused by the surface film.

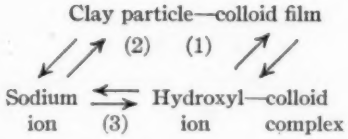
We conceive plasticity, as understood by the ceramic man, to be due to this surface film of colloidal material—amorphous or crystalline, organic or inorganic—and these films to be not of relatively great thickness.

If then we wish to control the force (yield value) required to induce flow, we must control the depth of the surface film. This can be done with electrolytes (charged bodies). If we add NaOH to such a system, we will upset the adsorption equilibrium. The ions of NaOH in equilibrium with the system will function as follows:

The negatively charged OH^- ions will attract the outer layers of the film material with greater force than the less negative clay particles, forming a colloid-hydroxide complex, which can be assumed to be either a

chemical individual or a colloid with OH^- nucleus. We prefer to consider it a very slightly ionized chemical entity. This process goes on until an adsorption equilibrium is set up.

During this process we have done two things—both of which will cause a fall in viscosity. We have removed the outer films from the clay particles, thus reducing their effective diameters, and so reducing friction. We have also displaced the practically electrically neutral bodies by bodies with like charges (negative), thus introducing repulsive forces, which will permit mobility. Schematically the equilibrium may be represented as follows:.



The positive Na ion is in electrostatic equilibrium with the two negatively charged bodies.

There is no tendency for Na^+ to be adsorbed on a positive film but a great tendency for a positive film to unite with a negative OH^- ion to form a colloid-hydroxide complex.

As the concentration of the ions of NaOH is progressively increased the tendency for action (1) to take place decreases due to progressive removal of positive colloid film, but for action (2) to increase due to increased negative polarity of the clay particle. Action (3) is of minor importance.

Viscosity falls while action (1) is in ascendance due to removal of film, plus repulsion of aforesaid friction inducing bodies, while it increases as action (2) increases due to decreasing polarity of friction inducing bodies. When polarity has approached zero, we reach a high point in viscosity due to internal friction but not in plasticity, as plasticity is induced largely by the *larger* clay particles with their adsorbed films, while now we have clay particles with thin films and loosely combined colloid—OH ion complexes.

If this is true, we would expect a curve with great pitch at first on addition of electrolyte that would taper off and then start up. This is what we actually do get.

If NaOH is added beyond a concentration sufficient to give a neutral body, it is possibly combined molecularly to form: (a) NaOH—film colloid complex, and (b) $NaOH\text{-}OH^-$—colloid complex, both of which are ionized, giving Na^+ and negative complexes which will again repel each other and lower viscosity.

When H^+ ion is added to such a system, the effect is to combine with the OH^- of the hydroxyl-film complex, thus forming H_2O and liberating

some of the positive colloid which is then free to be adsorbed as outer layers on the clay particles system.

It is in effect a driving of the equilibrium in the opposite direction thus effecting an increase of the plasticity producing film.

The flocculating or deflocculating effect of the ions of an electrolyte depends not only upon their polarity and concentration but also upon their transport numbers, the speedier ions such as H^+ and OH^- having the greater effect. The concentration of the hydrogen ion (pH) as measured against a hydrogen electrode should throw light upon flocculation and deflocculation. If such a theory as the above is correct one would predict a break in the curve at pH-7 and an increase in dispersion as the pH value increased and a flocculation when it decreased.

If the aging of clays is due to an increase of H ions, it may be explained as above suggested. Note that both the bodies capable of producing friction carry a negative charge, which agrees with cataphoretic considerations. The above outlined theory seems to clear up many of the physical changes which clay suspensions undergo. Any theory, such as the above, which seeks to explain physical phenomena is justifiable only if it explains known facts or if it points the direction in which research can hope to be productive. An enormous amount of exact experimental evidence is, of course, necessary to establish such a theory which in the case of clays is lamentably lacking. This phase of the work will be brought out in a subsequent paper.

Having thus taken considerable time to set forth my views (which are only a collection and expansion of already expressed theories) on plasticity, we will now consider for a while plasticity measurement.

Measurement

Many types of apparatus have been devised to measure this elusive property of clays and allied substances, but none of them has proved wholly successful, and as a result a great deal of preference is still expressed for the so-called touch or feel method.

In order to test out the reliability of this method so largely used in many quarters, we got the consent of five men, eminently fitted to judge clays, to undergo a series of tests, the results of which are shown in the accompanying table. Each observer tested five clays varying widely in degree of plasticity, ranging from ball clay to short kaolin. The first two observations were made blindfolded and the last observation was unrestricted. The observations were made several weeks apart and the observers were not aware that they were the same clays. The clays were made up to maximum plasticity just before each trial.

The four most satisfactory methods for measuring plasticity are probably

the so-called Bingham plastometer method, the Stringer-Emery method, the Atterberg tests, and the dye absorption method.

The last named has lately fallen somewhat into disrepute due to the fact that it is a measure of a particular colloid rather than the total colloid content of clay and assumes that plasticity varies directly as colloid content.

It is possible to get duplicate results far more consistently than by any other method, unless it be possibly the Bingham method, which has not as yet been fully tried out on clay–water systems. The explanation of course is either that the colloids found in clays are largely the same or that the adsorptive power of the different colloids does not vary widely, and that plasticity is very closely associated with colloid content.

In explanation of the accompanying table, Observer (1) in his first (*a*) trial judged Tenn. Ball to be third (3) in order of plasticity of the clays tested, placed it (3) on second trial (*b*) also. These first two (*a*) and (*b*) trials were under blindfold (touch). His third judgment unblindfolded

TABLE I

TABLE: SHOWING ORDER OF PLASTICITY OF CLAYS AS JUDGED BY OBSERVERS USING TOUCH METHOD AND BASIS FOR JUDGMENT

Clay	Tenn. ball			Weathered shale			Bentonite			No. 2 fire			N. C. kaolin			
Method of observation	Touch		Unrestricted	Touch		Unrestricted	Touch		Unrestricted	Touch		Unrestricted	Touch		Unrestricted	Basis of judgment
	(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		
Observer (1)	3	3	1	2	2	2	1	1	3	4	4	5	5	5	4	Smoothness Drying speed
(2)	1	2	1	2	1	2	4	4	3	3	3	4	5	5	5	Cohesiveness
(3)	2	2	2	1	1	1	3	3	3	5	5	5	4	4	4	Yield
(4)	1	1	3	2	2	2	3	3	1	5	4	4	4	5	5	Yield Cohesiveness
(5)	3	5	5	2	4	4	1	1	1	5	2	3	4	3	2	Adhesiveness Cohesiveness
Adsorption (dye)		3			2			1			4			5		
Atterberg test		3			2			1			4			5		

(unrestricted) was that Tenn. Ball was the first (1) in order of plasticity.

In the last vertical column is indicated the property upon which he claimed to base his judgment.

In the two lower horizontal columns are indicated the order of plasticity as determined by the adsorption and Atterberg tests.

It would seem, then, that the touch method is not reliable when carried out by different men, even under the same conditions. More than this, however, it is of course highly desirable to be able to state in concrete terms—a unit or series of units, if necessary—the *degree* of plasticity of a clay, so that a man on the Pacific Coast may understand a man in St. Louis, when he says one clay is twice as plastic as another, and not have to depend on the comparatives, very, most, little, least, etc.

Our literature, as well as our technology, suffers enormously from the lack of a standard of comparison. The first thing which needs to be clarified is a definition of terms. This we must have even before we can discuss intelligibly the factors involved.

It seems futile to try to measure a quantity upon which we are not agreed even to the extent of the factors involved. If, however, we can group all these unknown factors under one term, such, for instance, as "p," we can later dissect "p" in some such formula as the following:

$$p = \frac{deformation}{force} \quad or \quad p = \frac{flow}{yield\ value}$$

We know that in "p" are involved several factors, such as cohesion, adhesion, surface tension, etc., and it is very desirable that they should be determined, but we do not need to mark time until this is done.

Specific references have not been given in this article, but the published works of Bancroft, Zsigmondy, Roland, Odén, Washburn, Purdy, Ashley, Bingham, Atterberg, Stringer, Emery, Von Veimaren, Alexander, Schurecht, Mellor, and others have been freely consulted and used.

CERAMIC EXPERIMENT STATION
U. S. BUREAU OF MINES
COLUMBUS, OHIO
April, 1922

Discussion

BY MR. PURDY:—The correctness in definition of colloidality, as given by Mr. Bole, cannot be questioned, but it should be understood that an all-inclusive general definition is bound to be much too broad for any particular colloid. All-inclusive definitions are misleading as are such theoretical statements as "any kind of matter, may, theoretically at least, appear in the form of a jelly"—for practically many colloids have not been found in and cannot be made to assume the jelly-like condition.

Subdivision of matter may be one of the conditions of colloidality but fineness of grain *per se* is not the whole story of colloidality and certainly it is not the cause of distinguishing properties of different types of colloids. Types of colloids are distinguished by properties other than size of particle. It can be said, however, that with materials in the form of discrete particles, as the size of particle diminishes, its specific surface is increased and with this there is an increase in intensity of surface effects. The smaller the clay particle, the more pronounced will be its behavior as a colloid.

Among the several classifications of colloids, two are of particular interest to ceramists, (1) emulsoids, and (2) suspensoids. Very few materials correspond in all particulars with those that are pronouncedly and distinctly of one type or the other, but those colloids which do correspond in all particulars to each of these types have very pronounced distinguishing properties and physical reactions.

Is a clay a suspensoid or an emulsoid? There are different sorts of suspensoids and emulsoids, and each sort has its own peculiar properties but there are determining characteristics for each class.

Viscosity.—The viscosity of a suspensoid, whether it be a solution or a turbid suspension, is not much greater than the liquid medium or solvent and is not increased greatly with increased concentrations. Whereas, the viscosity of emulsoids increases with increased concentrations.

Clay "slips" agree more nearly with emulsoids in this respect.

Flocculation.—Suspensoids are easily flocculated by electrolytes while emulsoids are not.

Clay slips behave in this more like suspensoids.

Change in State.—The emulsoids when dried and rewetted will revert to the same physical state as before. Suspensoids will not as a class so revert. In this respect clays behave more like emulsoids.

These and other contradictions are not surprising, for colloidality is not any particular state or condition and is not predicated by any set of conditions and, therefore, there is no particular definition of colloidality.

Have plastic clay particles a film of material in a colloidal condition?

Put into another form this question can be: do the colloidal clay particles require a film of another material in colloidal condition in order to exhibit plasticity? If so, what is this plasticity-giving material?

Certainly the hydroxides of alumina and silica do not meet the requirements. They will not deflocculate with electrolytes. They will not revert to their original colloidal state after having been dried. Additions of any proportion of either of these hydroxides will not increase the plasticity of any clay yet experimented with; indeed after drying and rewetting, they decrease the plasticity.

Bole infers that this film about the clay particles is made up of yet smaller particles of the same material held by adsorption. The plastic, friction reducing material, according to this conception, consists of those clay particles that are so fine as to more nearly approach molecular subdivision.

This does not appear to me to be a necessary hypothesis. We have been unable to discover any colloidal material in clays essential to plasticity and have been unable, by addition of colloidal material, to increase plasticity. Certainly the finest portion of plastic clays obtainable by centrifuge separation neither subtracts from nor adds to plasticity.

It meets all the requirements in the way of a working hypothesis to assume that the plastic clay particles have sufficient specific surface (surface per unit volume) to allow the maximum development of the natural physical properties of the material, such as adsorption of salts, holding of a water film, and flocculating and deflocculating under the influence of a difference in tension between the salt water film and the salt solution in which the discrete clay particles are suspended. There is nothing in this assumption that is contrary or new to colloidal chemistry and it certainly plumbs more nearly with the several sorts of observations.

Much stress has been laid on the Brownian movement exhibited by some of the clay particles as evidence of electric charge. As a matter of fact, Brownian movement is evidence of a kinetic energy apart from electro static. Osmotic pressure (surface tension), Brownian movement and diffusion are markedly dependent upon the specific surface of the particles and not upon electric charges *per se*.

Clay particles are negatively charged and this is so whether flocculated or deflocculated. Flocculation by electrolytes does not render the particles neutral, as is evidenced by their traveling to the positive pole in electrosmosis tests. If the dielectric constant of the suspending medium is higher than that of the clay particle, as it generally is, the clay particle will show a negative charge. Flocculation and deflocculation has not been proved to be caused by changes in polarity of the clay particles. There is more evidence that flocculation and deflocculation result from tension differences.

A NEW TYPE OF GAS-FIRED VITREOUS ENAMELING FURNACE

By H. H. Clark

ABSTRACT

The furnace described in this article has a working chamber 4 feet wide by 3 feet high by 10 feet long, and is heated by ten gas burners, five on each side. Other proportions are made to suit the nature of the work to be enameled. City gas is most desirable, although any gas above the grade of producer gas may be used.

A furnace of this type can be brought to a working temperature in less than an hour, and will turn out from 12 to 24 loads of work an hour, depending on the kind of work being enameled.

The average gas consumption is about 1800 cubic feet of 500 B.t.u. gas per hour when firing about 600 square feet of flat ware totaling 690 pounds, representing 240 pieces, at an average temperature of 1700°F. The furnace runs without attention other than that given by the men who load and unload the fork.

Furnaces of the intermittent type have various features which are covered by patents issued and applied for. In addition to fuel economy, this type of furnace has the added advantage of producing ware of a very high gloss.

The first cost is low and no foundations other than the ordinary cement floor are necessary, as the entire furnace is above the floor level. Maintenance is practically nothing, as there is no muffle or combustion chamber.

If the following charts and photographs could be presented without further comment, leaving the rest to imagination, the author would be pleased, because to give all the details of a furnace such as this is very much of a problem.

On one hand the users of the furnaces hesitate about letting their competitors know about the improvements made in methods of burning on enamel that result in improved product and reduction of cost.

On the other hand the manufacturer objects to a detailed description of the furnace and of the method of operation for fear of losing a sale of his knowledge of such things. Ordinarily you cannot sell to a person that which you have already given to him. Then, too, a failure with a certain type of furnace because of faulty construction or incorrect operation makes difficult the promotion of such a furnace even under guarantee of correct construction and successful operation.

In this instance the writer is a third party who has represented both sides in the selection and operation of furnaces of this type, hence will endeavor to be fair with all parties concerned.

The general design of the furnace is shown in Fig. 1. Photograph of a furnace of this type, but without steel casing, is shown in Fig. 2. Figure 3 is an interior view of one of these furnaces after 20 months full operation, except for occasional shut-downs over Sunday. No repairs of any kind have been made, and indications are that none will be required for many more months.

Figure 4 is a photographic copy of pyrometer chart, showing how this type of furnace comes up to working heat after a 72-hour shut-down.

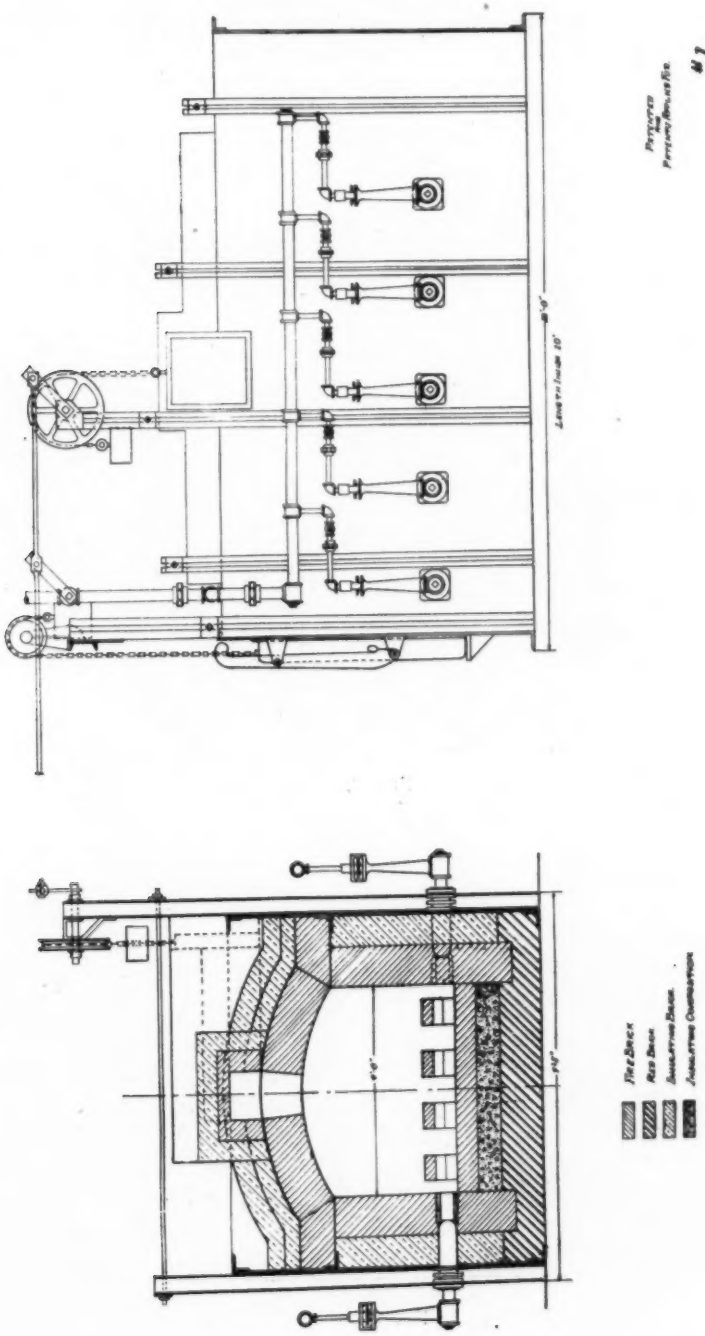


FIG. 1.

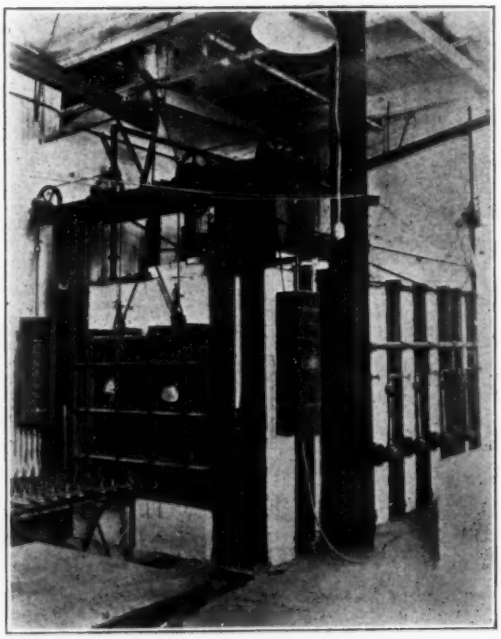


FIG. 2.

FIG. 3.

It also shows the variety of work done on that particular morning and an analysis of the chart runs about as follows:

4:10 Gas turned on. (Furnace at 750° after 72-hour shut-down)
4:53 Gas off. (Furnace at 1850° after 43 minutes firing)
4:55 First charge in
5:00 First charge out

From 5:00 o'clock until 7:35, a period of 2 hours and 35 minutes, a total of 36 loads was taken out of the furnace at a finishing temperature of 1600°F, consisting of 1003 square feet of first and second white coats on assortments of 22 and 24 gauge steel, consisting of splasher sides, panel tops, and broiler pans for gas ranges. Total net weight of material, 1140 pounds. Total number of pieces, 403. In addition to this, it required 220 pounds of supporting pins for each load, in order to give the proper support to this gauge of flat steel.

From 7:35 to 8:00 o'clock, 5 loads of ground coat, white, were taken out at a finishing temperature of 1700°F. Total square feet, 135. Net weight, 150 pounds. Total number of pieces, 50.

From 8:00 o'clock to 8:30, the furnace stood with the gas off while the workmen ate their meal.

At 8:30 the gas was turned on again and was ready for ground coat firing in 5 minutes, and from 8:35 to 9:20 a total of 10 charges of ground coat, white, were taken out at a finishing temperature of 1700°F. Total square feet, 270. Total net weight, 300 pounds. Total number of pieces, 100.

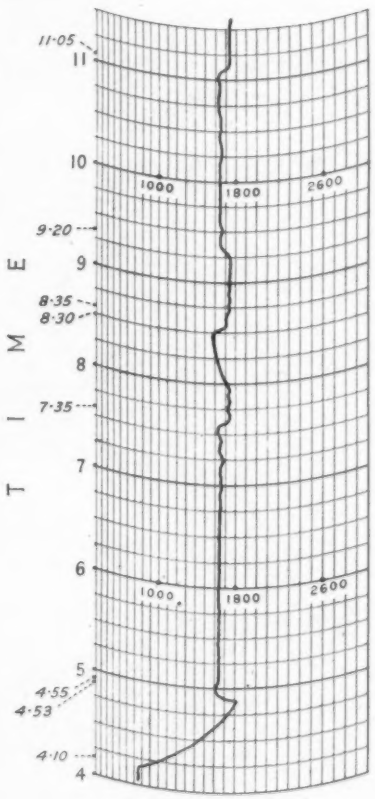


FIG. 4.

From 9:20 until 11:05 they resumed work on first and second white coat and put through 30 charges in this period at a finishing temperature of 1600°F, consisting of 1122 square feet. Net weight, 1295 pounds. Total of 438 pieces.

From 11:05 to 11:50 they were back on ground coat white, and in this period turned out 11 charges. Total square feet, 297. Net weight, 330 pounds. Total pieces, 110.

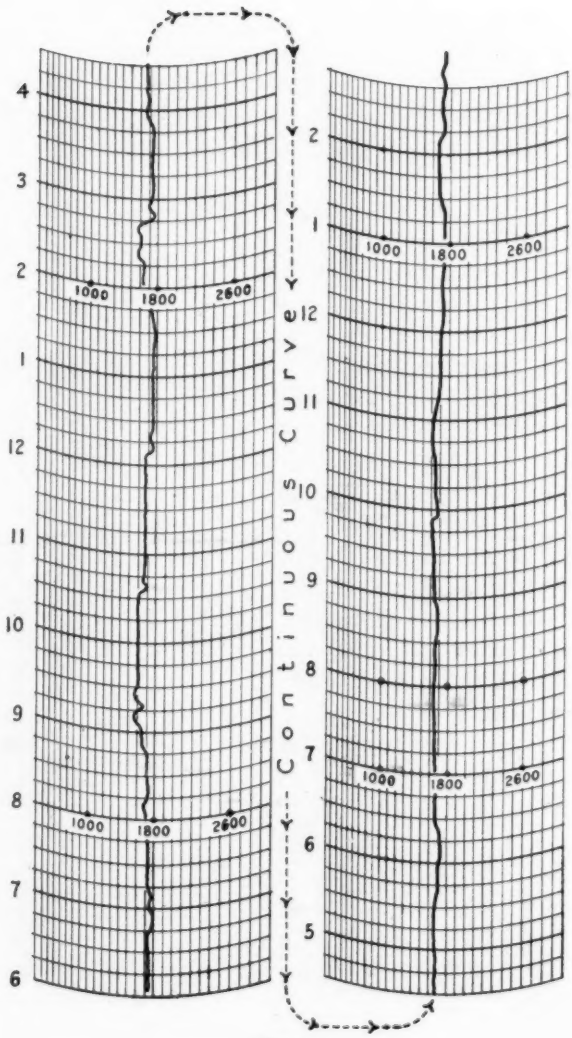


FIG. 5.

These figures, while taken from actual practice, are not the best obtainable, but are given to represent what can be expected under conditions as you find them the first few hours after starting the furnace after a shutdown of several days.

Figure 5 is a photographic copy of pyrometer chart for 21 hours' running, showing various temperatures for ground coat, first white coat, and second white coat on steel; also you will note 5 loads of cast iron were fired, 2 shortly after 9:00 and 3 more about 2:00 P. M. These were cast iron stove legs weighing approximately 3 pounds a piece, and 52 legs constituted a load.

Figure 6 is a photograph of a typical gas meter installation which is used for metering the gas to this type of furnace. The installation illus-

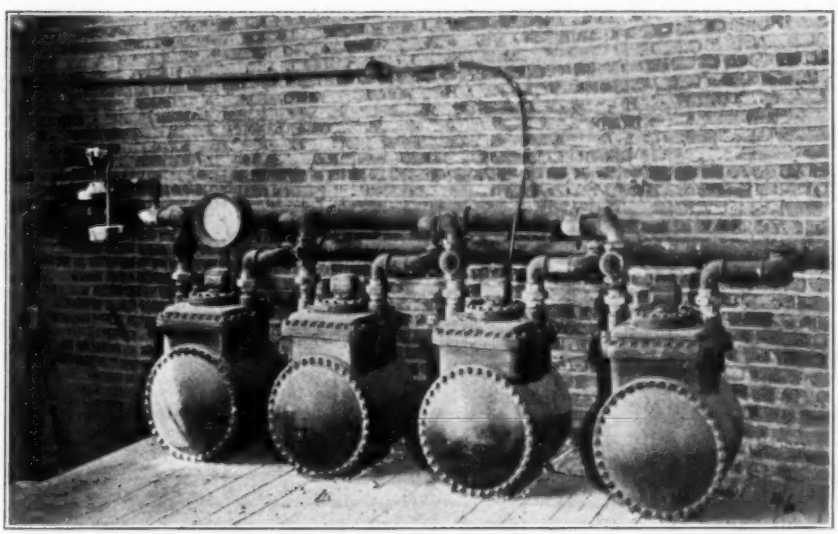


FIG. 6.

trated handles city gas of approximately 500 B.t.u.'s per cubic foot, and has a capacity of 24,000 cubic feet of gas per hour. The burning rate of each furnace is about 7200 cubic feet per hour, but for the short interval that the gas burns between loads, the gas consumed is less than 100 cubic feet per minute, and the total consumed is about 1800 cubic feet per hour. This installation will handle nicely, four of the furnaces described in this article, and this brings us to the item of cost.

The average gas consumption for the 21-hour period shown on Chart 5 was 1800 cubic feet of 500 B.t.u. gas per hour, and at 50 cents per thousand this would represent a total fuel cost of 90 cents per hour per furnace. There was no other expense in connection with the fuel because the air

for combustion is drawn in at the gas mixers by an automatic device known as an inspirator. The average production of material in this 21-hour period was 600 square feet per hour; average weight of material per hour, 690 pounds; average number of pieces per hour, 240; average finishing temperature, 1700°F. Two men did all of the work on this furnace, including loading and unloading fork, loading and unloading furnace, opening and closing the door, regulating the fuel, and so forth. The total labor

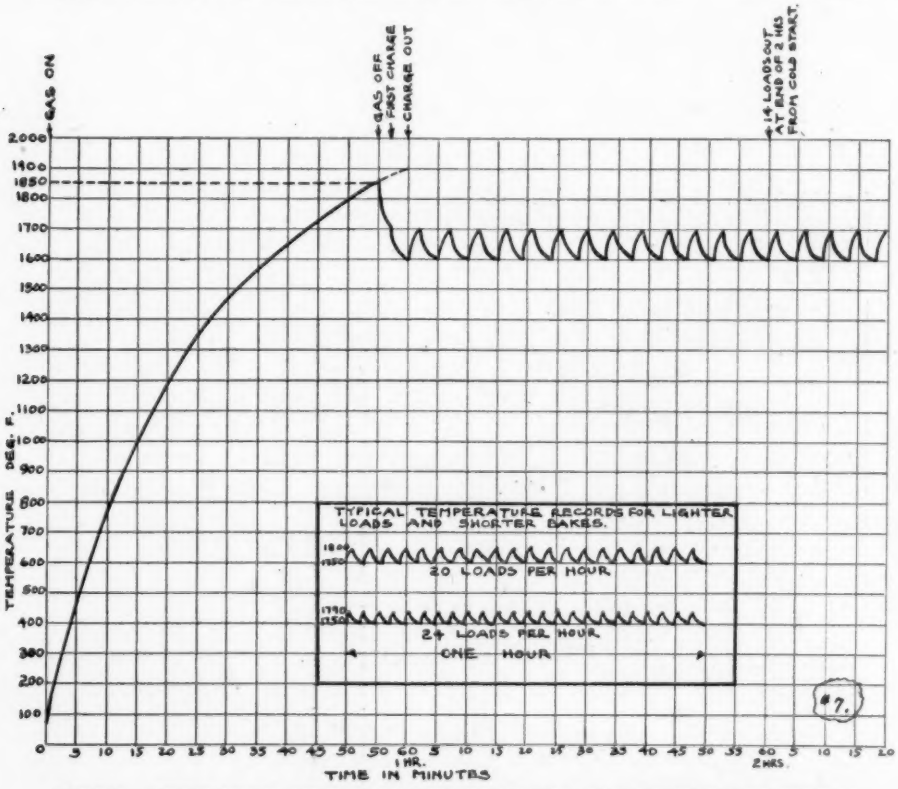

GAS ON
GAS OFF
FAST CHARGE
CHARGE OUT
14 LOADS OUT AT END OF 2 HRS FROM COLD START.
TEMPERATURE DEG. F.
TYPICAL TEMPERATURE RECORDS FOR LIGHTER LOADS AND SHORTER BAKES.
20 LOADS PER HOUR
24 LOADS PER HOUR
ONE HOUR
#7.
1 HR.
2 HRS.
TIME IN MINUTES
TYPICAL TEMPERATURE RECORD SHOWING START FROM COLD FURNACE TO WORKING TEMPERATURE AND PRODUCTION OF 14 LOADS OF MATERIAL, ALL WITHIN TWO HOURS.
NOTE:
ON 72 HOUR SHUT DOWNS, FURNACE DROPS TO 750° F. AND IS BROUGHT TO 1850° F. IN 45 MINUTES. BY INCREASING GAS SUPPLY AT BURNERS, EVEN GREATER SPEED IS POSSIBLE.

FIG. 7.

expense per hour was therefore two men at 50 cents each. This makes a dollar an hour for labor and 90 cents an hour for fuel, a total of $1.90 per hour, which, divided by the production per hour on the class of goods previously mentioned, is, labor and fuel, 32 cents a hundred square feet or 27 cents per hundred pounds. These costs can be further reduced by leaving supporting pins in the oven, for certain classes of ware, also by use of flue gases in waste heat boilers and dry rooms. No exact figures

have been obtained as yet, but indications are that leaving pins in the oven reduces fuel cost about 18 cents per hour per furnace, and heat recovered from the gases by boiler and dry-rooms represent a further saving of about 18 cents per hour per furnace.

Chart 7 is a typical temperature record showing the start from cold furnace to working temperature and production of 14 loads of material all within 2 hours. Inserted in this chart are some typical temperature

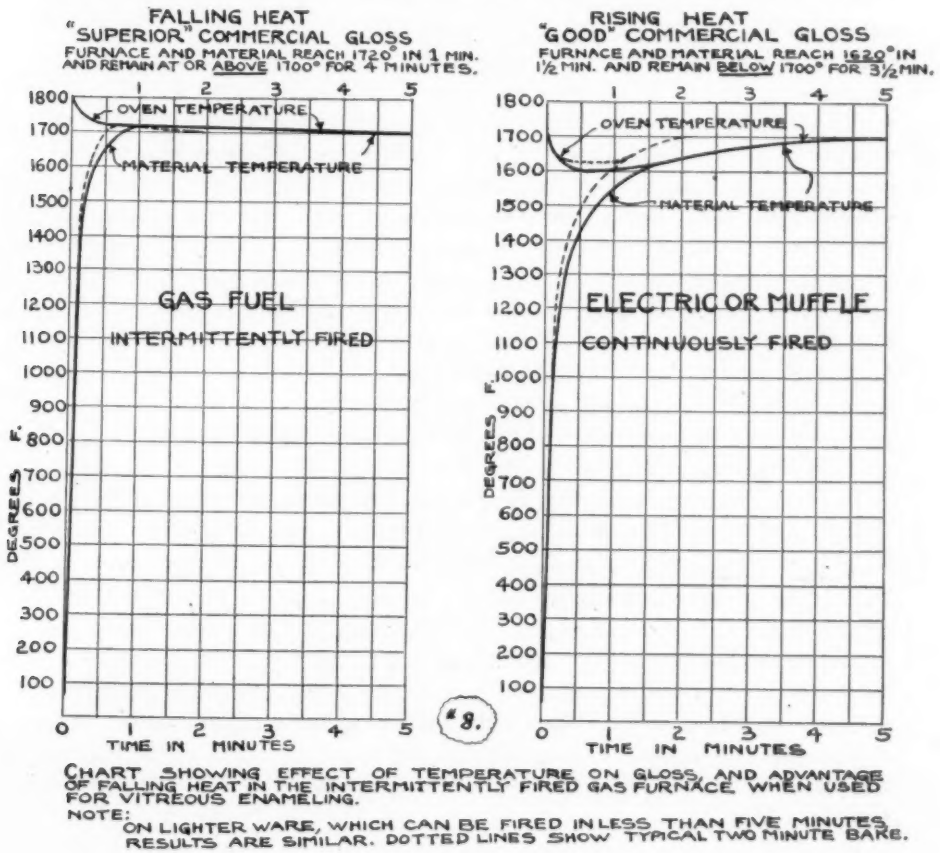

FALLING HEAT
"SUPERIOR" COMMERCIAL GLOSS
FURNACE AND MATERIAL REACH 1720° IN 1 MIN. AND REMAIN AT OR ABOVE 1700° FOR 4 MINUTES.
OVEN TEMPERATURE
MATERIAL TEMPERATURE
GAS FUEL
INTERMITTENTLY FIRED
DEGREES F.
TIME IN MINUTES
RISING HEAT
"GOOD" COMMERCIAL GLOSS
FURNACE AND MATERIAL REACH 1620° IN 1½ MIN. AND REMAIN BELOW 1700° FOR 3½ MIN.
OVEN TEMPERATURE
MATERIAL TEMPERATURE
ELECTRIC OR MUFFLE
CONTINUOUSLY FIRED
DEGREES F.
TIME IN MINUTES
CHART SHOWING EFFECT OF TEMPERATURE ON GLOSS, AND ADVANTAGE OF FALLING HEAT IN THE INTERMITTENTLY FIRED GAS FURNACE WHEN USED FOR VITREOUS ENAMELING.
NOTE:
ON LIGHTER WARE, WHICH CAN BE FIRED IN LESS THAN FIVE MINUTES, RESULTS ARE SIMILAR. DOTTED LINES SHOW TYPICAL TWO MINUTE BAKE.
"8."

FIG. 8.

records for lighter loads and shorter heats. These charts are taken from actual pyrometer records, but on account of the frequent charges and short intervals of firing, the pyrometer record shows almost a straight line, due to the slight lag in the thermocouple.

Chart 8 shows a very important point in favor of the intermittently fired gas furnace, because the finished goods have a very high gloss. This has been attributed to the fact that the fusing of the enamel takes place

at a falling heat. For example, when the door is opened to receive the goods, the furnace is at a temperature of 1800°F, although the desired finishing temperature is 1700°F. Careful observation with optical pyrometer and calculating the lag of our recording instruments indicate that it takes about a minute for the goods and the oven to come to the same temperature, and in doing this the furnace temperature drops about 80°F. Therefore, from that time on, whether the goods are in the oven 2 minutes or 3 minutes or more, they are under a slightly falling temperature which is approximately 3°F per minute.

Making similar observations on a muffle furnace, in which the finishing temperature of the goods was the same, namely 1700°F, we found that, not having the thermal head of 100° to start with, the temperature in the vicinity of the goods dropped to 1600°, and it took about a minute and a half for the oven temperature and the goods to equalize. After that period there was a slowly rising temperature, and if left in the oven approximately 5 minutes, the normal temperature of 1700° was restored; but if under these conditions the enamel was fused at 1600°F, it would evidently be still more liquid at the end of the bake, which would tend to thin the surface and diminish the gloss. On the other hand, if the enamel is compounded to be thoroughly melted at 1700°F, it only reaches this temperature for a fraction of the time, when compared with the intermittently fired furnace, which starts off with a thermal head of about 100° on heavy work and at least 40° on light work.

The big advantage of the gas fired furnace seems to be that, by distributing the fuel over a large number of small burners and designing them in such a way that combustion is self-starting and practically complete before the products enter the furnace chamber, rapid and economical combustion takes place, and the heat absorbed by the goods can be restored to the furnace in from 30 seconds to a minute and a half, depending on the class of work being enameled, or in any event within the time that it takes the 2 men to take the finished work off the fork and reload with work to be enameled. The opening in the main gas valve regulates the flow of fuel, and this determines the length of time to restore the furnace to proper heat.

In calculating the heat balance of the furnace on which these results were obtained, it is found that the average fuel consumption is about 900,000 B.t.u.'s per hour, of which about 15% goes into the enameled ware and about 20% into the loading pins. Here is where room for economy is possible, because on some classes of work the pins can be left in the oven. The other losses are radiation losses, flue losses, and heat lost each time door is opened.

In a furnace which is now under construction, the fuel consumption, it is thought, will be less than 700,000 B.t.u.'s per hour, because while no

change is contemplated in the method of loading with pins, it is planned to use automatic temperature control which will shorten the period in which the furnace is under fire, and compressed air operated doors will shorten the time that the door is open. Furthermore, this latest furnace is being built with 9″ of insulating brick inside of the steel casing, so that radiation losses will be reduced to a minimum.

SOME PROPERTIES OF ZINC OXIDE BODIES[1]

By Earl E. Libman

ABSTRACT

Melting Point of ZnO.—The melting point of ZnO is above 1800°C and may be above its normal sublimation point.

Volume Shrinkage and Porosity of ZnO Bodies.—A very hard and dense body composed of pure ZnO can be prepared. At high temperatures it exhibits the unusual phenomenon of volume shrinkage accompanied by an increasing porosity.

Zinc Retort Bodies.—In the discussion the possible advantages of incorporating zinc oxide in a zinc retort body are mentioned.

1. Introduction.—The data presented below constitute part of an investigation which had for its purpose the determination of the Phase Rule diagram for the system ZnO–Al_2O_3–SiO_2. It was found, however, that, using pure materials, most of the temperatures of the diagram were beyond the range of any furnace equipment which the Department possessed and the investigation was therefore abandoned. The few data which were obtained, however, may be of some value to others interested in the behavior of zinc oxide and it seems, therefore, worth while to place them on record.

2. Material Employed.—The zinc oxide employed was a "chemically pure" material having the following analysis:

Fe.....	trace
Cu.....	none
Cd.....	none
Mn.....	none
Pb.....	0.01%

3. The Sintering of Zinc Oxide.—The material employed was in the usual form of a light fluffy powder which, on heating to a bright yellow heat, volatilized rather rapidly. Since the vapor pressure of a substance increases with increase in the convexity of the evaporating surfaces, it seemed probable that the high volatility of ordinary zinc oxide is caused by the combination of a great surface exposed and a high vapor pressure due to the smallness of the individual particles.

In order, therefore, to reduce the surface and to increase the size of the crystals, a sample of the zinc oxide was first placed in a desiccator and allowed to stand over damp filter paper until it had absorbed about 20 per cent of water. This moist material was found suitable for pressing, and cylinders 1.5 cm. in diameter by 5 cm. long were pressed out in a hardened-steel die, using a large hand operated screw press. These cylinders were then dried and the surface layer removed to eliminate any possible contamination with iron from the surface of the die. The cylinders

[1] Received March 8, 1922.

were then placed in a small platinum box with a tightly fitting cover and heated in a platinum resistance furnace to a temperature of 1400°C and held there for several hours.

Upon cooling, the cylinders were found to be extremely hard and stone-like. The outer surface was dark brown and numerous crystals, some as wide as 0.5 mm., had developed. The brown coating was found to be confined entirely to the surface, the inner portions of the cylinder showing a sparkling, coarsely crystalline aggregate. The dark superficial layer was

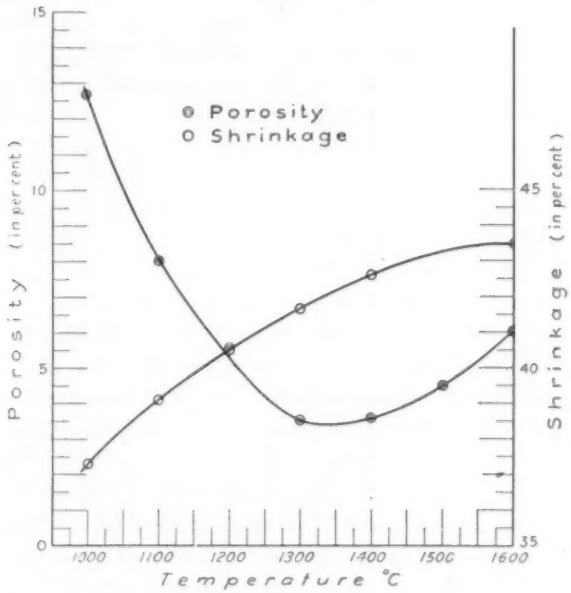


FIG. 1.

ground off and upon analysis was found to contain 0.07 per cent Fe_2O_3, the source of which was probably the platinum box in which the sticks were fired. The interior portions of the cylinder after crushing and grinding in an agate mortar gave a yellow, heavy, crystalline powder, having the following analysis:

Fe.....	trace
Pb.....	0.01%
Cd.....	none
SiO_2.....	0.03%, probably from the agate mortar
Al_2O_3.....	trace, probably from the alundum furnace tube

It was estimated that if the yellow color of the powder was due to iron not more than 0.0005 per cent Fe_2O_3 was present. No attempt was made to determine the crystallographic properties of the crystallized material,

but its general appearance under the microscope as well as its density (5.4) indicated that it was the mineral zincite.

4. Melting Point of Zincite.—A sample of material held for 48 hours at 1710°C showed no signs of fusion. A stick of the material was then heated in an oxyacetylene flame, using the apparatus and method described in a previous paper.[1] It was possible in this way to heat the end of a stick to a black-body temperature of 1800°C. It is not improbable therefore that the melting point of zincite is above 2000° and it may be that its sublimation temperature under atmospheric pressure is lower than its melting point.

5. The Burning Behavior of Zinc Oxide Bodies.—Cylinders of commercial zinc oxide were prepared by the dust-press process described above. After drying, their bulk volumes were obtained with a small mercury volumeter of the Seger type. They were then placed in an alundum-tube furnace wound with a platinum heating coil and were fired at the rate of 200°C per hour, trials being drawn at the following temperatures, 1000°, 1100°, 1200°, 1300°, 1400°, 1500° and 1600°C, respectively. The heating curve of the furnace as indicated by a platinum platinum-rhodium thermocouple was recorded on a Hoskins automatic recorder.

The burning shrinkages and porosities are shown in Fig. 1. The porosities were obtained by means of the Washburn-Bunting porosimeter.[2]

6. Discussion of the Volume and Porosity Changes.—The volume shrinkage curve shows that the material shrinks uniformly with rising temperature, but the curve shows no breaks or peculiarities corresponding to the peculiar changes that are found in the porosity curve. The porosity-temperature curve shows that the porosity decreases gradually to a minimum at 1350°C and thereafter increases. This peculiar behavior is apparently due to the gradual growth of large crystals at the high temperatures, these crystals being very dense, but being separated from one another by small cracks or interstices which grow in size with the crystals, consequently producing an increase in the porosity. It is probable that a body made from pure zinc oxide would gradually disintegrate at high temperature, owing to this slow crystallization.

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Discussion

By E. W. Washburn:—During use a zinc retort body gradually changes in composition owing to the absorption of zinc oxide and the resultant body contains a large amount of this material. Zinc oxide itself, as Mr. Libman's results show, is a good refractory and it is practically certain that from

[1] Washburn and Libman, *Jour. Amer. Ceram. Soc.*, **3**, 637 (1920).

[2] Washburn and Bunting, *Ibid.*, **5**, 112 (1922).

the substances Al_2O_3 (introduced as fire clay) SiO_2 and ZnO a highly refractory zinc retort could be manufactured. There is also the additional possibility of being able to obtain a retort body which would be practically unattacked by the charge during operation. The principles to be followed in meeting this condition are known but in order to apply them the Phase Rule diagram of the system is required and this has not yet been worked out. The construction of this diagram offers no insurmountable difficulties and the requisite furnace equipment is on the market. If the zinc industry would coöperate in supporting research in this field some extremely valuable and fundamental scientific data would result which would enable us not only to understand exactly what happens in a zinc retort during usage but would also point the way toward the scientifically ideal retort body.

THE HARROP TUNNEL KILN

By W. E. Cramer

ABSTRACT

The successful application of the car tunnel kiln to the firing of electrical porcelains is described. This kiln is 321 feet long, 54 1/2 inches wide inside, and has a placing height of approximately 60 inches. The ware is placed in saggers as formerly. Ware has been fired through this kiln in 48 hours—total time for heating up, soaking, and cooling. The kiln operates at cones 10, 11, and 12, depending upon the ware being fired. Natural gas is used as fuel and is supplied to the kiln through Maxon Premix burners. Auxiliary fuel oil equipment is also installed.

The tunnel kiln located at the plant of the General Porcelain Co., Parkersburg, W. Va., is a Harrop kiln of the direct fired type and is firing low tension electrical insulators, special porcelain and a general line of standard electrical porcelain. It is equipped for burning either fuel oil or natural gas or the two fuels can be used together. The kiln is so constructed that with a few minor changes in the furnaces, coal can also be readily used for fuel.

Construction on the kiln proper was started on March 4, 1921, and it was completed on July 14, 1921, at which time it was started in operation.

The kiln is housed in a Milliken fabricated steel building which is 60 feet wide and 350 feet long. This building is bolted together throughout having steel window sash, steel doors and concrete floor which makes it an ideal kiln building.

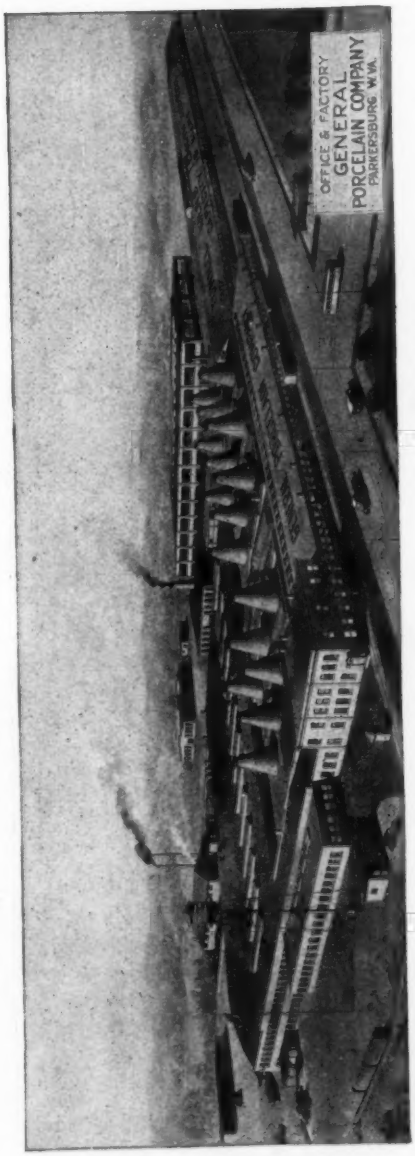
The kiln is 321 feet in length and the inside width is 54 1/2 inches. The overall height is approximately eleven feet. Of the 321 feet in length, 160 feet is taken up in the heating up zone, 42 feet in the firing zone and 119 feet in the cooling zone. The firing zone includes eight furnaces, four on each side of the kiln, which are in staggered relation.

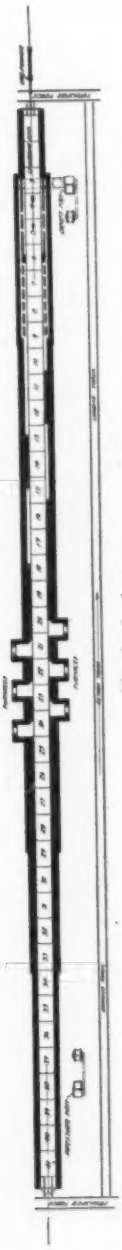
The kiln car is six feet long and 58 1/2 inches in width, the effective setting space being fifty and one half inches by five feet nine inches. The metal parts of the car are protected from the high temperature by sand seals which extend the entire length of the kiln. The cars are propelled by an automatic hydraulic ram.

The burners used on the kiln are the Maxon-Premix type. They are so arranged that either gas or oil can be used and a change can be made from one fuel to the other at a moments notice. If desired both fuels could be used together.

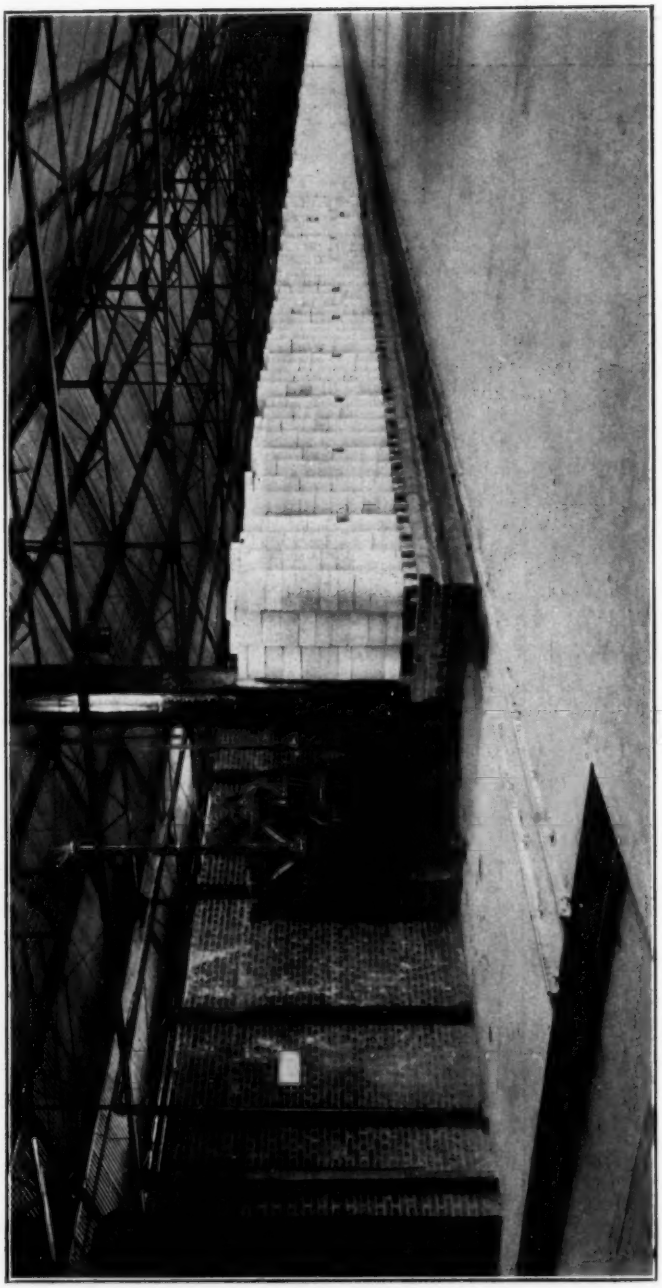
The total power required to operate the kiln is twenty-one motor horsepower. This represents the motor horsepower provided but it is calculated that only about eighty per cent of this power is used under normal operation.

There are four firemen required to operate the kiln, in two turns of twelve hours each with two men on each turn. These men attend to charging the





Typical plan.



Charging end of kiln showing loaded cars.

cars in the kiln, removing them from the kiln, and also the regulation of the heat which requires attention when there are three different firing temperatures used. That is, in firing three different kinds of ware the kiln must operate at either cone 10, 11 or 12 and be quickly changed from one temperature to another. This change can be easily made by regulating the burners and the car schedule in from one to two hours.

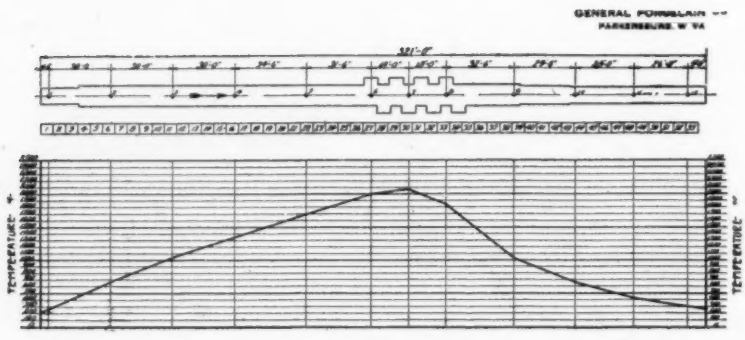
The kiln has been operated at a car schedule as fast as fifty minutes and as slow as one and three quarter hours. When operating at a one and one half hour schedule or slower it is sufficient to fire two furnaces on each side of the kiln to obtain good results, but a faster car schedule requires the use of three furnaces on each side.

The entering temperature of the kiln varies between 100°F and 220°F. The heating up curve is practically a straight line until it reaches the burning temperature of cone 10, 11 or 12. Then the temperature drops off quickly and then more slowly as it nears the end of the kiln. The discharge end temperature varies between 175°F and 350°F.

The cooling air is first drawn under the cars from the atmosphere by means of a suction produced by the air supply fan. From under the cars it is drawn through the fan and tempered with atmospheric air and then divided three ways. Part of it is forced into the discharge end of the kiln and serves for cooling the ware. The second part is forced through a flue over the entire discharge end of the kiln from where it is led down over the furnace arches and delivered into the furnaces as secondary air for combustion. The third part is circulated through hollow walls in the furnaces where it is preheated and then can be led to the burners or forced through the grates as primary air for combustion. The temperature of the air as it comes from under the cars has been found to be 340°F when the kiln was operating at cone 12. As this same air enters the discharge end of the kiln after being tempered its temperature is 165°F.

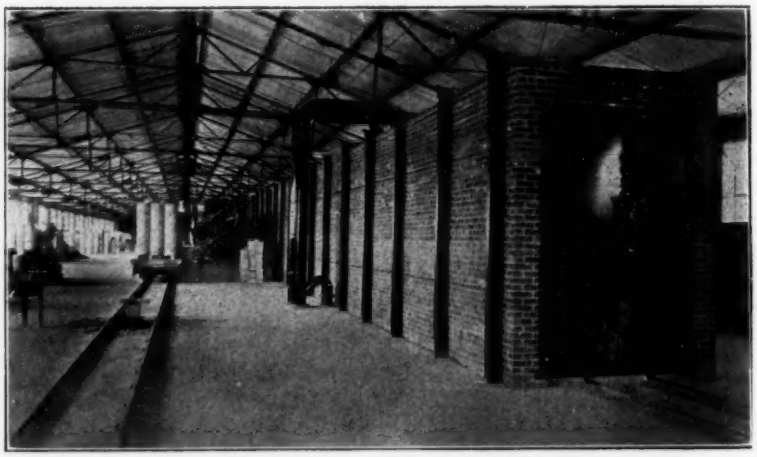
The combustion gases leave the furnaces and enter directly into the tunnel proper, travelling horizontally toward the charging end. Near the charging end they enter flues in the side walls of the kiln and are taken out by the draft fan. The temperature of these gases as they enter the stack is 350°F.

The cross-sectional heat distribution has been excellent. At times the tops of the car setting has been about one half of a cone easier than the bottoms. However, this has been easily remedied by the proper adjustment after which practically every sagger on the car received the same temperature. In August, 1921, a car loaded with one hundred and twenty five-inch saggers, every one containing cones and ware trials, was run through the kiln in order to determine the cross-sectional heat distribution. It was found that each sagger received practically the same amount of heat, there being but a quarter of a cone variation throughout the entire setting.



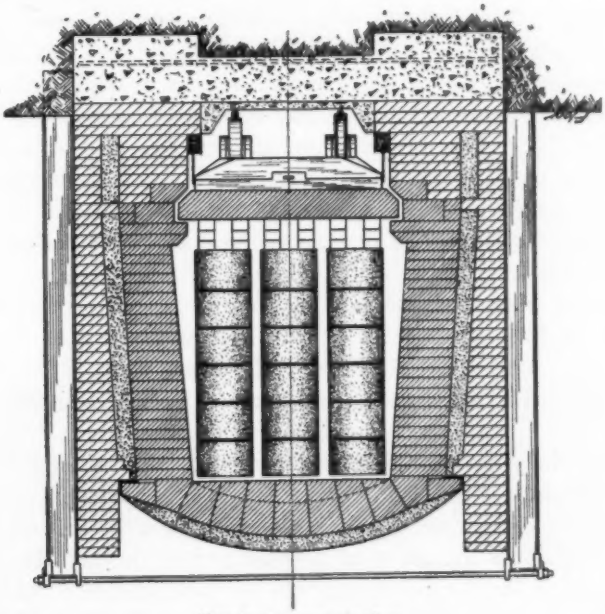
TEMPERATURE RECORD
HARROP CONTINUOUS TUNNEL KILN

DATE Aug 30, 1921 HOUR 9½ A.M. CAR SCHEDULE 1½ hrs CONE 12 TAKEN BY W.E. Cramer



Discharging end of kiln.

The top saggers of the setting were slightly easier than the bottom saggers. Later it was found that, unlike other kilns of the car tunnel type, it was possible to maintain continuously a higher temperature along the bottoms of the setting than along the tops. This condition is undoubtedly due to the construction of the inner walls of the kiln which allows an easier passage of gases through the bottom of the setting. This is an exclusive feature of the Harrop Kiln. The car setting is three bung wide and the center bung is as well fired as the two outer ones. It was found that the same results were obtained when the saggers were set tight across the car but with a space between them lengthwise as when the setting was very loose. This again shows that there is good circulation throughout the kiln.



Typical cross-section.

The kiln was designed to have a maximum capacity equivalent to the drawing of twelve sixteen foot diameter periodic kilns per week. Using thirteen and one half inch diameter round saggers it requires seventeen kiln cars of ware for the equivalent of one periodic kiln. Thus a fifty minute schedule will give the above capacity. Using square saggers the amount of ware placed on a car can be increased by 55%. These saggers are now being made and will undoubtedly increase the saving and efficiency of the kiln.

The kiln will hold fifty-two cars in its length. Thus at an hour schedule a car will remain in the kiln fifty-two hours, twenty-six hours being used

in the heating up zone, seven hours in the firing zone and nineteen hours for cooling. This gives a saving of approximately 35% in firing time over the periodic kilns.

It is interesting to note that the average weight of one car loaded with green ware ready for the kiln is slightly over ten thousand pounds, the weight of an empty car being four thousand pounds. The pusher is of ten tons capacity and to propel the fifty-two cars is required but nine thousand four hundred pounds total pressure.

A fuel test conducted during the summer of 1921 shows a fuel consumption of 195,300 cu. ft. of gas in 36 hours with a production of 35 cars. At this time six furnaces were under fire. This gives a consumption of 5,580 cu. ft. per car or 94,869 cu. ft. for the equivalent of one periodic kiln. Another test was conducted while four furnaces were under fire. Twenty-four cars were produced in thirty-six hours and 130,000 cu. ft. of gas was consumed. This is 5,416 cu. ft. per car or 92,972 cu. ft. for the equivalent of one periodic kiln. Meter readings taken during the month of November, 1921, show that the average gas consumption per hour on an operating schedule of one hour and twenty minutes is 4,200 cu. ft. of gas. This shows a considerable saving over the periodic kilns.

During the five and one half months that the kiln has been operating it has been found that there is a saving in labor amounting to the elimination of one man in placing and one man in drawing the equivalent amount of ware in a periodic kiln. The odd work around the kiln is practically the same as around a periodic kiln. However, there is the elimination of maintaining the bags, cleaning out the flues and building up the doors.

There have been practically no repairs on the kiln since it was started. One of the thermocouple welds broke but it was rewelded and replaced. Twice through carelessness it was necessary to shut the kiln off for several days. One time the fireman went to sleep and let the cars stand too long, resulting in a wreck. From the time the kiln was shut off until it was back up to temperature it was but eighty-four hours, during which time the temperature did not fall below 800°F. Another time through careless regulation of the burners a bung of saggers was caused to fall, thus requiring another short shut-down.

The kiln has shown its advantages over the periodic kilns. First of all it produces a uniformly fired product which is impossible in the periodics. It has a large fuel saving over the periodic kilns. It also has enabled a lower individual labor cost due to the fact that all placing and drawing is centralized and much easier than in the other kilns. Finally it has proved a pacemaker for the entire plant. That is, when the tunnel is operating at a certain schedule the other departments know that they have to handle a certain quantity of ware in order to keep up.

The installation cost of the kiln was considerably less than the cost of the number of periodic kilns necessary to give the same production.

Due to business conditions the kiln was closed down the latter part of December, 1921, for a couple of months. Upon cooling a close inspection was made of the kiln. It was found that but few small cracks had developed on the outside of the kiln as a result of cooling. The inside of the kiln was in perfect condition after having been in operation five and one half months. It was particularly noticeable that the expansion joints had functioned perfectly.

COLUMBUS, OHIO

THE CONTROL OF GLAZE-FIT BY MEANS OF TENSILE TEST SPECIMENS[1]

By F. H. Riddle and J. S. Laird[2]

ABSTRACT

The selection of a suitable glaze for a particular body by usual inspection of a field of glaze trials is not sufficiently precise, and gives no indication of slow crazing tendencies.

A new method of selecting glazes depends on the effect of a glaze on the strength of a porcelain tensile test specimen. The best fitting glazes increase the strength while poorer ones decrease it. Glazes which craze weaken the specimens very markedly. Results obtained with various glazes on one fire porcelain are given.

Introduction

When a glaze is selected by a systematic study of a tri-variant system, it is found as a rule that within a field of considerable area the glazes appear equally suitable, that is, the composition may be varied considerably without developing crazing, shivering, under-maturing or over-firing. The selection of the best glaze within this field has been largely a matter of judgment, and the best glaze could not be assumed to be the one most nearly central in the field of good glazes. It is frequently the case that a glaze which appears satisfactory when newly fired will develop crazing on standing. This is particularly troublesome in the case of bright glazed wall tile which have an unfortunate habit of crazing anywhere from a month to several years after being cemented up in a wall, even though they may have shown no signs of crazing when newly fired or even when stored in air for a long time.

Attempts have been made to devise tests which would indicate quickly any tendency for an apparently suitable glaze to develop crazing. The tests have usually involved subjecting the specimens to rapid variations in temperature, much wider than those to which they would ever be subjected in use. These methods while of value for the particular products for which they have been devised are not of very general applicability.

A new direct method for comparing different glazes as regards fit has been devised in this laboratory, based upon the effect which a glaze exerts on the strength of a porcelain tensile test specimen.

Preparation of Specimens

Test specimens of diameters 0.4–0.5 inch are used, similar to those used in the tensile testing of metals, modified as necessary on account of the difficulty in loading a material of the degree of brittleness of porcelain.

[1] A contribution from the Research Laboratories of the Champion Porcelain and Jeffery-Dewitt Insulator Companies.

[2] Received April, 1922.

They are formed by turning in the green state, and after glazing and firing are broken on an ordinary cement testing machine, as described in detail in an article, "The Determination of the Tensile Strength of Porcelain."[1] The preparation of the specimens differs from that of test specimens for determining the tensile strength of porcelain bodies in that they are glazed all over (except the ends) while at least the central portions of the tensile strength specimens are left unglazed.

A number of specimens are made up from one body, glazed with the various glazes to be compared and fired together all in the same sagger when possible and in a large kiln. At least ten specimens glazed with each glaze should be prepared and tested.

Effect of Glaze on Strength of Specimens

The glazing of a small porcelain object such as one of these test specimens may (*a*) materially increase, (*b*) have little effect on (*c*) markedly decrease its breaking strength. These effects appear to be determined by the degree of success with which the glaze has been fitted to the body.

Thus, in the following series of tests the composition of a particularly good one-fire porcelain glaze maturing at cone 16–18 was modified by the addition of increasing amounts of a certain ingredient, so that while the maturing range of the glaze was not affected noticeably, crazing was developed with the higher members of the series.

The test specimens were taken from a large batch made mechanically, *i. e.*, blanks were cut from pugged one-inch rolls, and turned to a definite size. All the specimens were fired in one sagger in a commercial kiln. Each result is the average strength of several specimens.

TABLE I

SERIES OF CONE 18 GLAZES WITH INCREASED CRAZING TENDENCIES

Glaze used	STRENGTH Lbs. per sq. in.	Remarks on glaze
No Glaze	8,890	.....
Glaze 255	10,245	Standard
Glaze 255 A	9,135	Very good
Glaze 255 B	4,338	Bright, but distintly crazed
Glaze 255 C	3,592	Bright, badly crazed
Glaze 255 D	3,437	Opaque, crazed

The falling off in strength with the development of crazing is very marked, dropping to only one-third with the poorest glaze. A marked decrease in strength is, however, shown by glaze 255 A, which in appearance is equal to 255, and from which it differs in chemical composition by only 1.25%.

[1] Riddle and Laird, *Proc. A.S.T.M.*, **21,** 1050–56 (1921). Riddle and Laird, *Jour. Amer. Ceram. Soc.*, **5,** 385 (1922).

The following table shows results with one-fire cone 13 porcelain with various glazes.

TABLE II

Glaze no.	TENSILE STRENGTH Lbs. per sq. in.	Remarks on glaze
22	7,520	Good bright glaze
16	6,954	Good bright glaze
691 D	6,590	Somewhat pinholed
665	5,710	Immature, mat
666	2,052	Crazed, immature

Table III gives results with a number of cone 18 glazes none of which showed crazing by usual inspection but which showed marked differences by these tests. It may be noted that the glaze selected as a result of these tests has proved extremely satisfactory and reliable for use on spark plugs, the tensile strength tests being confirmed by impact tests. Glaze No. 666 was very white and of high covering power but weakened the body to which it was applied.

TABLE III

Glaze no.	STRENGTH Lbs. per sq. in.	Remarks on glaze
644	10,876	Good, slightly vesicular
255	10,324	Good, slightly eggshell
665	10,178	Very good
649	9,779	Poor, vesicular
653	9,622	Very good
647	9,622	Good
646	9,578	Poor, vesicular
648	9,454	Poor, eggshell
652	9,382	Good
664	9,200	Poor, mat
650	9,184	Good
645	9,033	Poor
651	8,973	Good
654	8,632	Good
655	8,432	Good
666	8,119	Very good
663	7,552	Poor

Conclusions

There can be no question as to the intimate relationship between the fit of the glaze and the strength of small glazed porcelain objects such as spark plugs, or with one or more small dimensions as rods, tubes, plates, etc. This relation probably holds true to a considerable extent for porcelain objects of any size or dimension, as for example high tension insulators. Failure of the glaze to fit, especially when the fit is so poor that crazing develops, produces strains in the surface of the porcelain so that failure

occurs under a much smaller external load than when the porcelain is free from such strains. On the other hand proper selection of a glaze results in a strength notably greater than that of the unglazed ware, an increase which can not be referred with one-fire porcelain to increased vitrification of the body due to soaking in of the glaze.

No experiments along this line have been made with semi-porcelain or the unvitrified bodies used in bright glazed wall tile, but it seems probable that in these cases also this method could be successfully used in the selection of glazes.

DETROIT, MICH.

DISINTEGRATION OF SODA LIME GLASSES IN WATER[1]

By Arthur E. Williams[2]

ABSTRACT

Soda lime glasses have been treated in water at temperatures below boiling point, at boiling point, and up to 25 lb. pressure in an autoclave. Effects produced are illustrated with photographs and show that glass disintegrates, *i. e.*, cracks, spalls, and loses weight when treated at any temperature used. The rate of disintegration depends upon time, temperature, composition, and heat treatment of glass surface during forming, the latter factor apparently affecting considerably the tendency to spall or chip.

Treatment given glasses conforms in many ways to treatment glass receives in service, either when sterilized when used for food packing or continued washing and sterilizing as when used for delivering or serving food daily. The relative endurance of glasses may be studied by the methods used, and standard methods of testing based upon them can be worked out. An article must stand at least six hours in boiling water without apparent disintegration or chipping to be of good quality.

Spalling always appeared on the exterior only of pressed or blown ware. Disintegration of the glass is cumulative with time of treatment whether it be periodic or continuous treatment. Treating glass in hot water with increasing pressures does not seem to give greatly increased disintegration as the temperature and pressure rises.

Surfaces of blown or pressed articles are shown to be laminated rather than smooth and impervious.

Introduction

Glass used for the daily delivery or serving of food and for the packing of food must stand repeated washing and sterilizing or several hours continued sterilization. Although glass is being made which stands these requirements in a satisfactory manner, there are also many cases where the life of the article is short, or it fails to endure the increasingly severe conditions being required of it. The following tests have been made to develop a means of determining the factors affecting the life of glass articles in service. Some very significant facts have been observed.

These experiments were confined to the treatment of soda lime glasses in distilled water at temperatures below boiling, at the boiling point, and in boiling water at pressures above atmospheric pressure.

Photographs illustrating some of the disintegrating action observed in the experiments are shown herewith. A brief description and discussion of these will be given previous to correlating the results.

Action of Water at Temperatures below Boiling

Figures 1, 2, and 3 show the results of immersing large battery jars in water at about 60°C for two months. The interior of these jars contained no water but held a few dry samples of sheet glass, the water surrounding the jars to about one inch from the top. Cracking and spalling on the jars

[1] Glass Division, St. Louis Meeting, Feb., 1922.

[2] By permission of the Director of the Bureau of Standards.

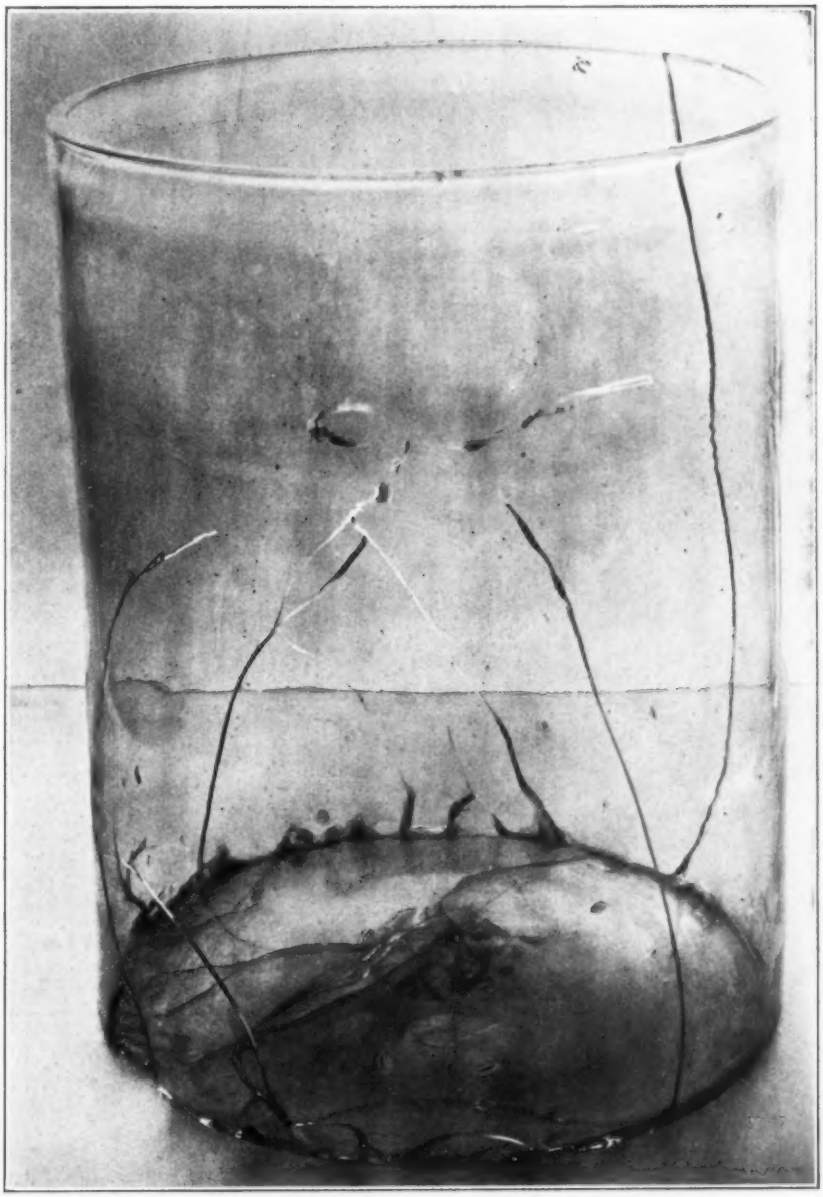


FIG. 1.

FIG. 2.

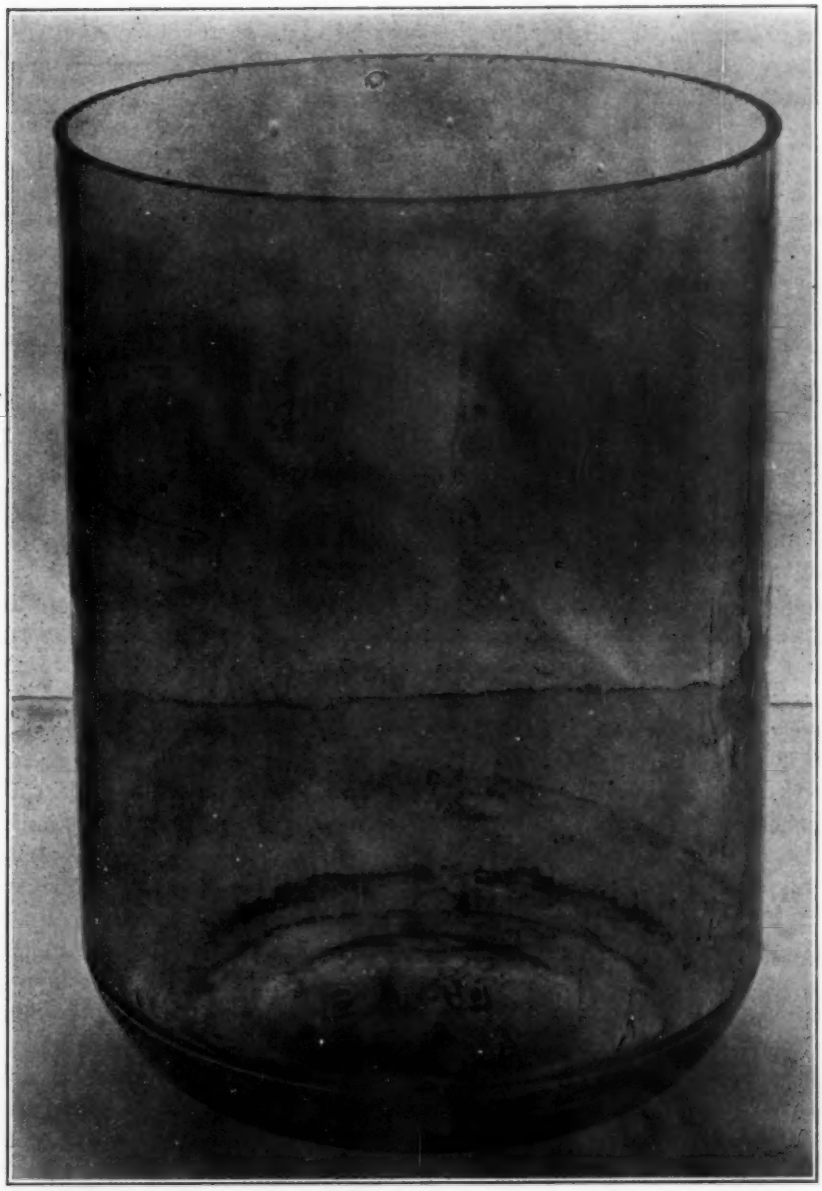


FIG. 3.

shown in Figures 1 and 2 began to appear after about two weeks' immersion. The cracks grew larger continuously and the spalled areas increased with time of immersion. Figure 3 is a battery jar of different composition and make, which was exposed to the same conditions as those shown in Figures 1 and 2, but did not give any evidence of cracking or spalling.

Action of Boiling Water

Figure 4 illustrates the effect of six hours and twelve hours continuous boiling on two types of commercial soda-lime tumblers. Tumblers 1 and 2, Fig. 4*a*, made of the same glass have been boiled six and twelve hours respectively, and illustrate what should be expected of a glass of good enough quality to warrant a reasonable life in service. Tumblers 3 and 4, Fig. 4*b*, treated in the same manner illustrate a glass which cracks in washing and of low mechanical strength. This latter glass contains but 5% of alkali earth oxides and less than 70% of silica which should be considered a glass of very poor composition.

Continued boiling of these articles would have produced a continuous increase in disintegration. This disintegrating effect is cumulative in action, in that periodic boiling for short intervals will show very similar results to a continued boiling for an equal length of time. Tests on a number of makes of tumblers and bottles show that a very great variation in the degree of disintegration may be obtained, some glasses being much more stable than the best shown in the illustrations.

Boiling Water at Pressures above Atmospheric

A distinct increase in the amount of disintegration produced for a given length of time is shown with temperatures of water increased above the boiling point. Figures 5 and 6 are photographs of tumblers and milk bottles treated in an autoclave at 0, 5, 10, 15, 20, 25, 30, and 50 pounds steam pressure for a period of 6 hours. While the effects of the treatments do not seem to increase in the same ratio as the pressures, the depth as well as the area of the spalls increases with pressure or extended treatment. Prolonged treatment results in a breaking up of the article. Six hours treatment at 5 pounds pressure is equivalent to about 24 hours continuous boiling at atmospheric pressure.

It was observed that spalling was confined to the outer surfaces in all cases. Grinding the edges of pieces of glass before treating them in the autoclave resulted in greater disintegration. The interior surface of different articles was scratched and roughed by shaking with shot, water, and carborundum, after which they were autoclaved. In this case spalling was observed on the interior. This would seem to indicate that the spalling on the exterior was due in part to a rougher surface than that on the interior.

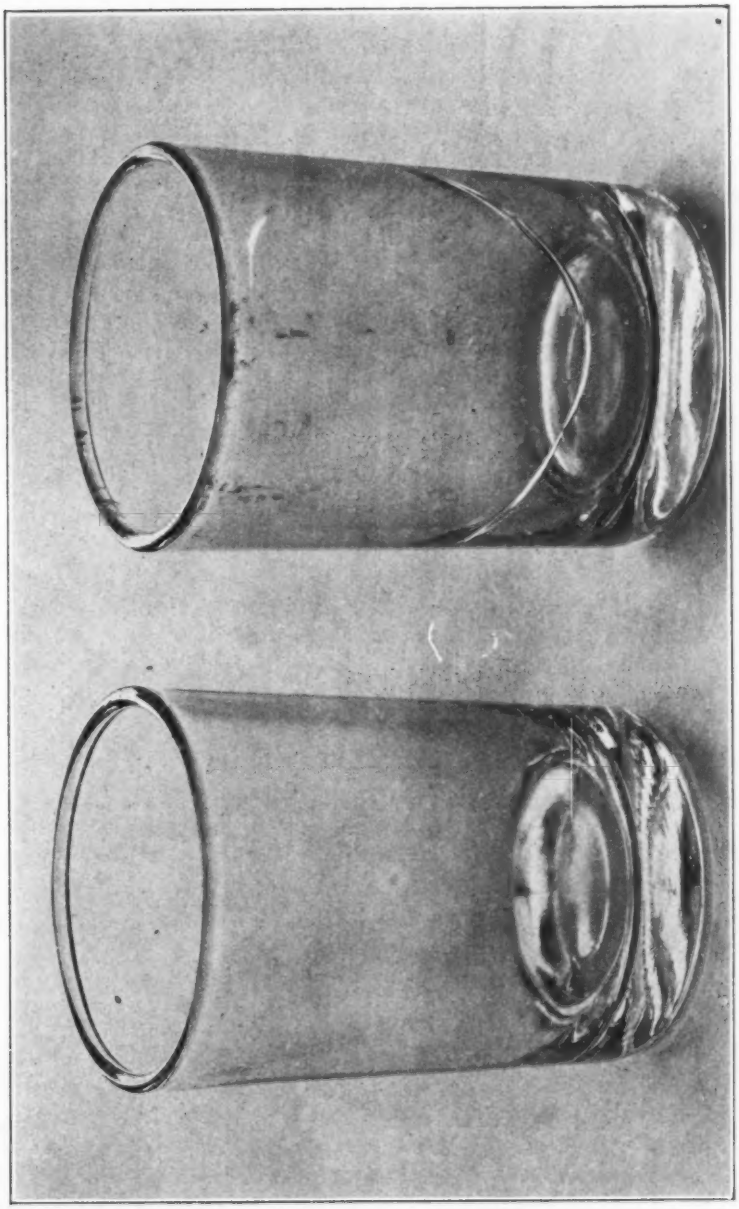


FIG. 4a.

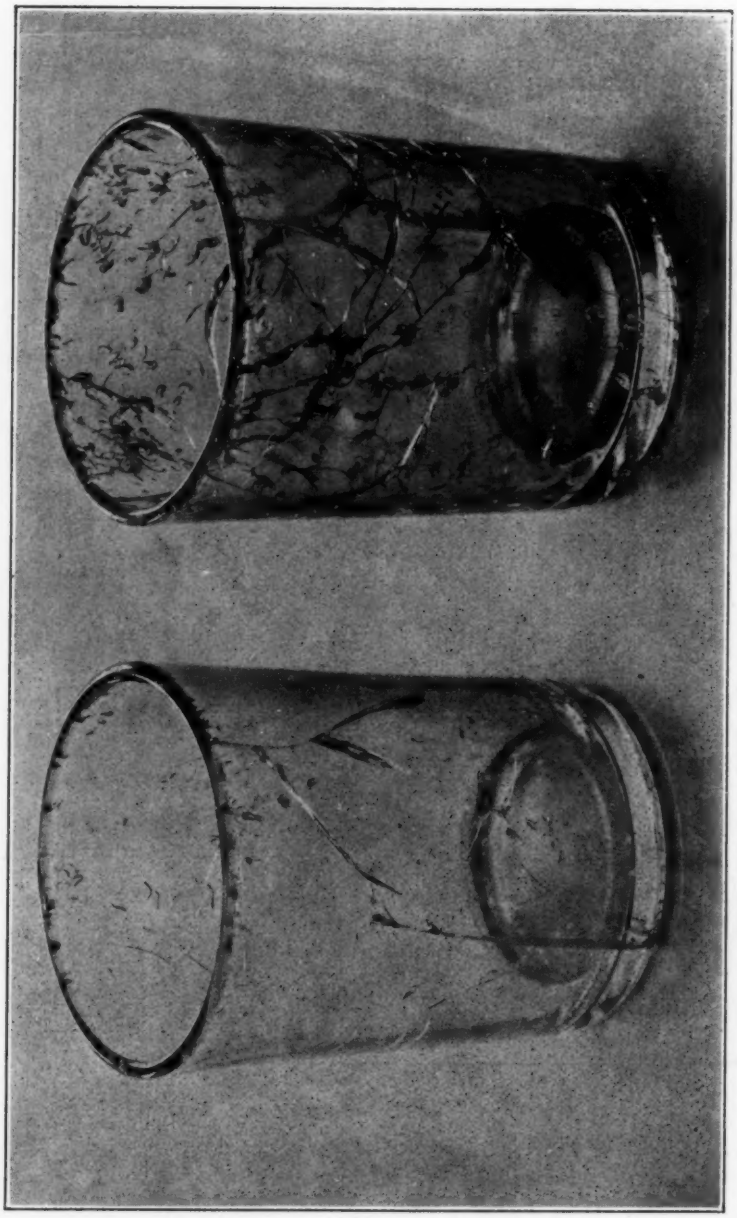


FIG. 4b.

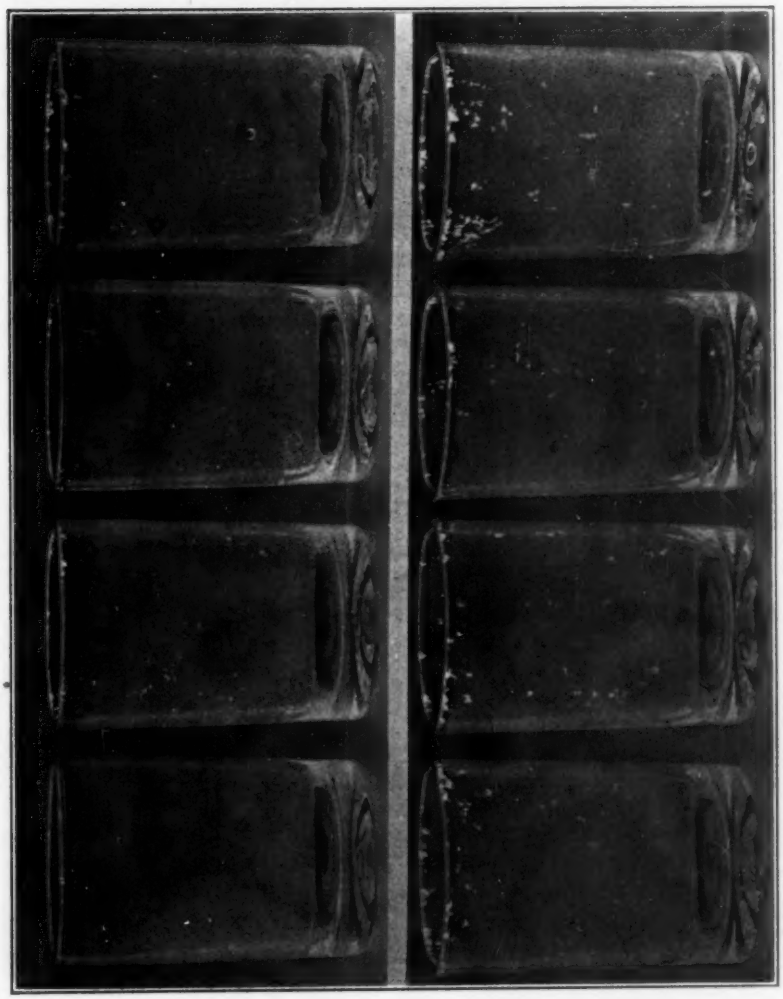


FIG. 5.

FIG. 6.

Figures 7 and 8 show the results that were obtained in an effort to smooth the exterior surface submitting the article to the autoclave tests. The deformed bottle and tumbler have been heated to the softening point (515°C) and then annealed. These articles together with those not heated were autoclaved at 50 pounds pressure for six hours. The entire absence of any spalling on the reheated articles indicates the importance of a proper surface condition. It is evident that a mere drying out of the article is not sufficient, as articles heated and annealed at temperatures at 50 degree intervals up to 400°C show no reduction in amount of spalling. Softening of the surface or a complete removal of surface strains is apparently an important factor, 450°C having been found to be the minimum temperature at which spalling ceased, which is within the temperature range required for annealing this glass. Treating a glass of poor composition in the same manner will not prevent spalling, hence the importance of both composition and surface condition.

Figure 9 illustrates a very interesting development. These tumblers were both treated in an autoclave at twenty-five pounds pressure for 6 hours and then dried at about 250°C, the tumbler on the right having been previously heated to its softening point and then re-annealed, the tumbler on the left having had no preliminary treatment. The effect is to produce on the tumbler not reheated an etched surface consisting of scale-like flakes of glassy material. These scales appear as approximately parallel curved lines which give the appearance of flow lines of the glass in pressing or blowing. This scale is found on both the interior and exterior of pressed and blown articles.

The question immediately arises, whether the glass in flowing actually tears, the scale being the remainder of the surface left after a certain amount of leaching has been done, or whether the condition is due to some other cause. Observations completed so far do not justify a positive answer.

Correlation of Observations

Reviewing the various facts observed, there is shown:

1. The chipping or spalling exhibited in the various accompanying photographs is always on the exterior, whether it be pressed or blown ware, except the type illustrated in Figure 9.

2. The effect of spalling is cumulative with increased time of treatment, in that ultimate disintegration appears whether the glass is treated in hot water periodically or continuously. Poor glasses show spalling after six hours boiling, whereas glasses having a sufficiently high silica and lime content require from 12 to 30 hours boiling to show any signs of disintegration.

3. Treatment in hot water with increasing pressure does not seem to give

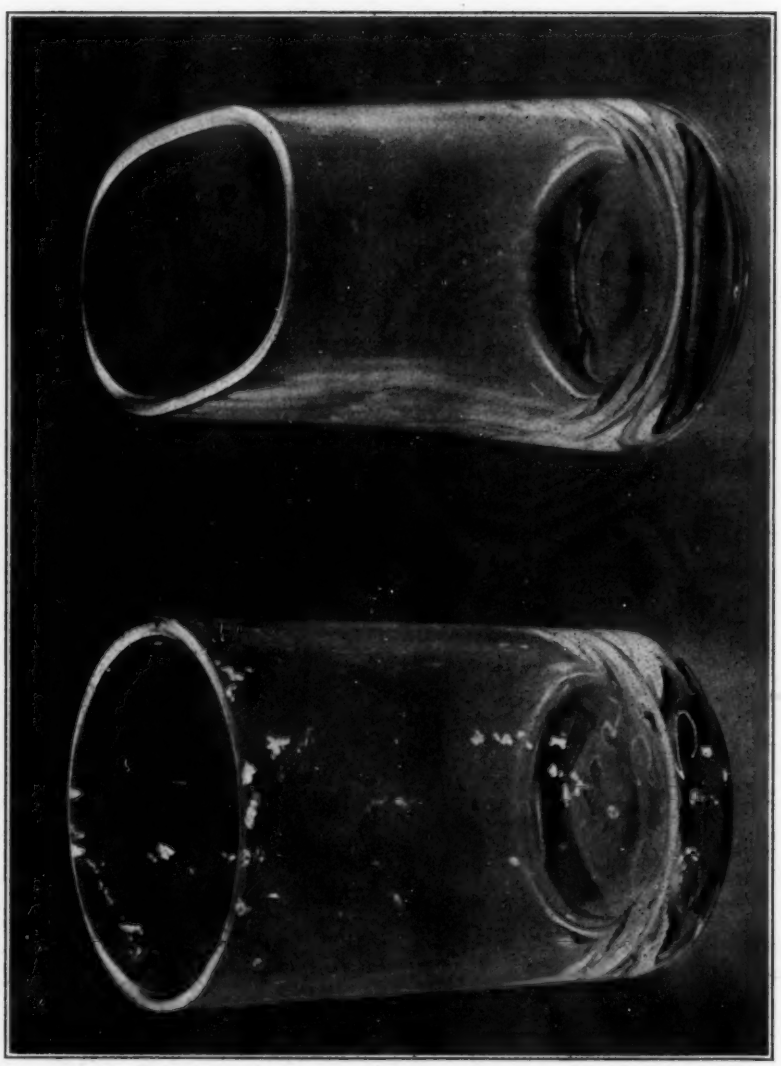


FIG. 7.

greatly increased disintegration as the temperature and pressure rise, especially on articles which are resistant to water at atmospheric pressure.

4. Although the amount of disintegration appears to be a function of the solubility of the glass the physical condition of surface is also shown to be an important factor. Reheating to the temperature (450°C) found

FIG. 8.

necessary to avoid spalling in the samples shown does anneal the glass and may close minute surface cracks by softening of the surface layer. Chilling or tearing of the outer surface as compared to the inner surface, might be explained in a blown article as it comes in contact with a mold only on the external surface. Pressed ware, however, is subjected to metal contact on both surfaces and as the plunger is often water cooled the inner

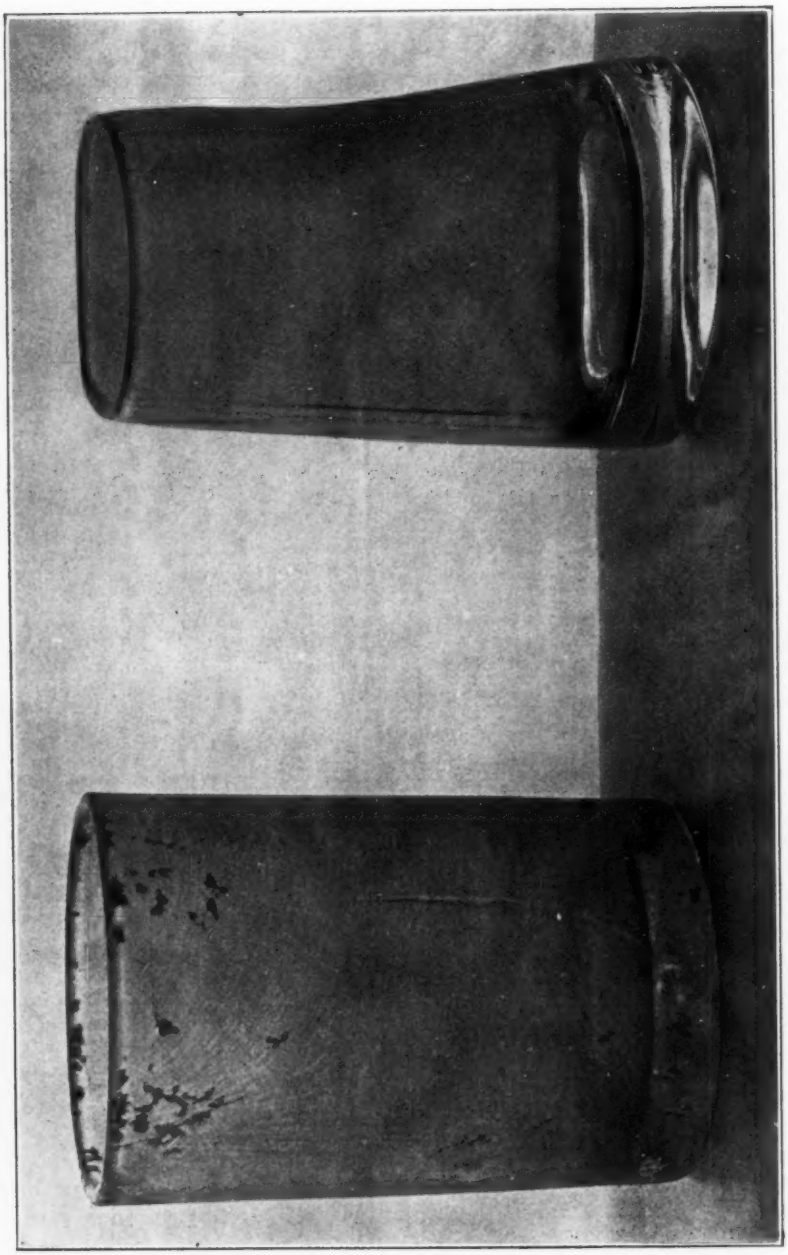


FIG. 9.

surface may be the more suddenly chilled. Just what is the physical difference between the outer and inner surface of the ware, such that spalling occurs only on the former, has not been determined as yet; but, as shown by Figure 9, both surfaces are subject to disintegration.

5. Articles which are treated for long periods in hot water will often crack. Sudden temperature changes are not needed to develop cracks, which seem to be due to strained glass. Hand finished goblets which did not crack after being filled several times with boiling water, cracked after several hours' boiling. These cracks were identified as being due to poor annealing, since they were found to be strained, and well-annealed goblets of the same make did not develop such cracks.

6. Articles which spall do not always crack, and articles which crack do not always spall. Cracking usually occurs only after moderately long treatment in water, regardless of whether the article spalled or not.

Summary

Treating soda lime glasses in water at high temperatures for a continuous period of six hours or more seems to be a very satisfactory means of indicating their resistance to the treatment certain types of ware are required to endure in service, and to indicate the general mechanical strength of the ware.

The evidence obtained is sufficient to show that both the composition and the mechanical condition of the surface are important factors. While in pressed and blown wares the interior surfaces of both kinds appear to behave similarly and the exterior surfaces of both kinds are also apparently alike, there does appear to be an important difference between interior and exterior surfaces, regardless of the process of forming.

In glasses of comparatively resistant composition, softening or reheating the surfaces seems to be the only treatment necessary to prevent spalling. Glasses having a low resistance to solution and disintegration, however, are not made immune to spalling or chipping by reheating.

The character of the results obtained indicate that the experimental methods used are capable of detecting weaknesses of a character which develop in service. It is proposed to continue the work for the purpose of collecting more evidence regarding the nature of the failures occurring.

U. S. Bureau of Standards
Washington, D. C.

NOTES ON SHIVERING OF TERRA COTTA[1]

By John L. Carruthers

ABSTRACT

Six terra cotta clays are tested for shivering as a body trouble using a white mat glaze, at cone 3 starting. One non-shivering clay and one badly shivering clay are experimented with, to produce and overcome shivering.

Causes of Shivering.—From this work and that of others which has been checked, causes are

(1) presence of *finely divided silica* in the body, from
  (*a*) highly siliceous clays
  (*b*) finely ground grog of a siliceous nature
(2) presence of soluble salts in the clay, grog, or tempering water
(3) longer firing periods

Methods of Eliminating Shivering.

(1) Use of a flux such as feldspar, *felsite*, or similar rock to overcome action of fine silica
(2) Use of coarse grog or sand
(3) Use of barium carbonate to overcome effects of salts

Shivering and crazing are the glaze and body problems that nearly all manufacturers of terra cotta or other glazed clay wares have had to contend with at one time or another. A great deal of experimental work has been done by this Company in previous years, in an effort to eliminate shivering by fitting the glazes to the body, and a small amount of work had been done toward correcting the body. The results were quite successful, with only occasional shivering taking place, probably due to variations in the body. In the summer of 1921, a great deal of shivering trouble occurred, and due to the fact that it seemed practically impossible to correct the trouble by changing the glazes, a study of the constituents of the body was undertaken, with the purpose of fitting the body to the glazes in use.

An investigation of ceramic literature shows that there is a difference of opinion among some of the investigators, as to the causes of shivering. Some of their work has been with white ware bodies, and the theories presented have seemed in accordance with some of the results of this work, hence they are included in the following references.

E. E. Gorton[2] notes that a body high in clay substance does not shiver.

H. R. Griffen[3] found that the addition of a siliceous clay to a body would cause shivering and that the addition of a feldspar to such a body would overcome the trouble. In his opinion, "shivering originates as a body failure and that the subsequent glaze shiver is a secondary reactionary consequence of the body failure." He also claims, "that while shivering

[1] Terra Cotta Division, St. Louis Meeting, Feb. 28, 1922.

[2] *Trans. Amer. Ceram. Soc.*, **1**, 84 (1899).

[3] *Ibid.*, **2**, 135 (1900).

and crazing are the results of strains set up due to a difference in the expansion coefficients of the body and glaze, the expansion coefficient of the glaze is always the greater. The relative strength of the body and glaze determines which shall appear, shivering occurring when the body is the weaker." He further states as his opinion, "that there are two conditions of standing between the body and the glaze, the first in vitrified bodies due to the coefficients of expansion, being brought so close together as not to produce a strain in excess of the elastic limit of the body or glaze; and the second, in porous bodies, where, while the strain is great, the powers are balanced, the factors being the relative strength and the elasticity of the body and glaze."

In the discussion[1] it was the opinion of some that shivering in terra cotta bodies was produced by sulfates in the clay and grog.

M. A. Coates[2] caused shivering to occur in a terra cotta body by the addition of a soluble salt. The degree of shivering was the same for

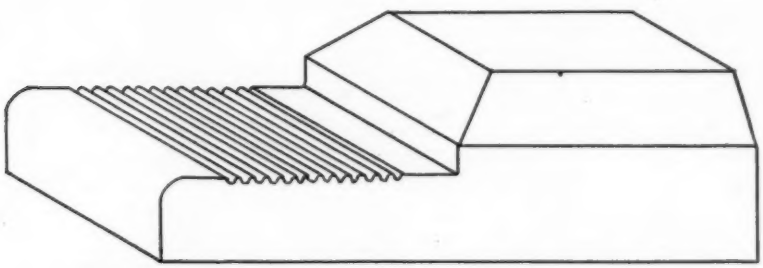


FIG. 1.

either a small or large addition of the salt. The addition of a fixer such as barium carbonate overcame the trouble.

R. H. Minton[3] found that the introduction of as low as 5% of flint to a non-shivering terra cotta body, caused shivering to take place, and that shivering increased with further additions of flint.

The chief points brought out by previous investigators are the following:

(1) Shivering can be produced in non-shivering bodies or clays by the addition of a siliceous clay or ground flint.

(2) Shivering can be produced by the addition of a soluble salt to non-shivering body or clay.

(3) Shivering can be overcome by the addition of feldspar to the body.

(4) Bodies high in clay substance do not shiver.

In making the tests described later, all clays were ground to pass a 10-mesh sieve. Bodies were made by volume parts rather than by weight,

[1] *Trans. Amer. Ceram. Soc.*, **9**, 520–27 (1907).

[2] *Ibid.*, **16**, 162 (1914).

[3] *Ibid.*, **17**, 310 (1915).

so as to follow factory practice. Bodies were pugged by hand to the consistency of the regular terra cotta body. Test pieces of the shape shown in Fig. 1 were pressed in a plaster mold. This shape of piece was used because it has been our experience that shivering occurs mostly on 45 degree bevel edges and on drove or tool finish. After removing from the mold, the pieces were finished and dried. Then the test pieces were sprayed with three coats of a white mat glaze which had shivered badly in factory use. The pieces were fired in a commercial terra cotta kiln to cone 3 starting.

Formula of White Mat Glaze:

$$\left.\begin{matrix}0.166\ KNaO\\0.005\ MgO\\0.412\ CaO\\0.417\ ZnO\end{matrix}\right\}\ 0.2029\ Al_2O_3\ (1.57\ SiO_2 + 5\%\ SnO_2)$$

Preliminary Tests.—Five Colorado clays, which we were using or had used, and one Indiana clay, which we knew to be successfully used in some other terra cotta plants, were each made into two bodies—one of six parts clay and four parts grog, and the other of the clay alone. Table I gives the analyses of these clays.

TABLE I

	A	B	C	D	E	F
SiO_2	58.7%	68.7%	72.8%	66.1%	66.7%	51.5%
Al_2O_3	26.6	18.2	15.9	19.8	18.3	32.9
Fe_2O_3	1.7	2.0	2.6	2.1	2.3	1.4
TiO_2	n.d.	0.7	0.4	0.5	0.8	0.1
CaO	0.1	1.4	0.7	1.0	1.6	0.8
MgO	0.8	0.6	0.6	0.5	1.2	0.4
KNaO	2.9	1.8	2.6	2.7	3.0	1.1
Ign. Loss	9.5	6.8	5.1	7.5	7.1	12.3
Total	100.3	100.2	100.7	100.2	101.0	100.5

Key to Table I:

A. A buff dense burning Indiana clay.
B. A fairly plastic buff burning Colorado clay, having a sandy feel.
C. A fairly plastic buff burning Colorado clay, having a sandy feel.
D. A very plastic buff burning Colorado clay.
E. A very plastic buff burning Colorado clay.
F. A very plastic white burning Colorado fire clay.

Results.—Bodies made with clays A and F did not shiver, while those containing D and E gave only slight indications of shivering, and bodies from B and C shivered badly. Bodies made without grog shivered worst. For further study, clays A and B were chosen from the above group in order that a comparison of a non-shivering clay and a badly shivering clay (under conditions at hand) might be made.

B-9
B-8
B-7
B-6
B-5
B-4
B-3
B-2
B-1
F-4
F-3
F-2
F-1
C-4
C-3
C-2
C-1
D-9
D-8
D-7
D-6
D-5
D-4
D-3
D-2
D-1
E-6
E-5
E-4
E-3
E-2
E-1

FIG. 2.

Bodies of the composition shown in Table II were made up to determine the effect of different sized particles of SiO_2. White silica sand and flint were used raw and calcined (cone 3) in this and another series but no difference was noted in the effect of either, hence only one series is shown. No attempt is made to determine any limits in this work and consequently all results are of a qualitative nature rather than quantitative.

TABLE II

	1	2	3	4	5	6	7	8	9
Clay A	6	6	6	6	6	6	4	4	5
Grog	4	4	4	4	4	4	–	–	–
Sand (10 M.)	–	1	2	3	–	–	–	–	–
Sand (20 — 40 M.)	–	–	–	–	–	–	6	–	–
Sand (150 M.)	–	–	–	–	–	–	–	6	–
Flint (200 M.)	–	–	–	–	1	2	–	–	5

Results.—Bodies 1, 2, 3, 4, and 7 showed no indications of shivering Bodies 3, 4, and 7 are very porous and open. Bodies 5 and 6 show slight shivering, and bodies 8 and 9 are badly shivered, No. 9 being the worst.

Because the bodies (n Table II) containing coarse silica particles did not shiver, the series shown in Table III was made to ascertain the effect of coarse silica, if added to a body that was known to shiver.

TABLE III

	1	2	3	4
Clay B	6	6	6	6
Grog	4	4	4	4
Sand (10 M.)	–	1	2	3

Results.—Body No. 1 shivered badly and the others much less, No. 4 showing only slight indications of the trouble. As the percentage of sand increased, the body naturally became more porous.

Previous to the last outbreak of shivering, the clay storage yard was filled with about three feet of flood waters. The water had swept over the salt coated grounds of a nearby chemical works. That some of these salts were left in the clay and grog when the piles dried out, has been established by analysis. The following tests were made to check the theory of soluble salts in terra cotta bodies, as being the cause of shivering. Fifty pounds of each of the clays and grog used in the body was soaked in a tub of water for four days, with occasional stirring. The water was evaporated down to a few gallons in each tub and then siphoned off. The waters from the different tubs were then put in one container and the bulk evaporated until about 1200 cc. was left. This water was used in the tests as indicated in Table IV.

TABLE IV

1. Clay A + Water No. 1
2. Clay A + Water No. 2
3. Clay A + 2% Na_2SO_4 + Water No. 1
4. Clay E + Water No. 1
5. Clay E + Water No. 2
6. Clay E + 2% Na_2SO_4 + Water No. 1
7. T. C. Body + Water No. 1
8. T. C. Body + Water No. 2
9. T. C. Body + 2% Na_2SO_4 + Water No. 1

N.B.—Water No. 1—Artesian well water.
Water No. 2—Concentrated leachings.

Bodies 3, 6, and 9 were covered with a heavy coat of salt when dry. Most of this salt was brushed off before applying the glaze.

Results.—Bodies 1, 7, and 8 did not shiver. Body No. 4 shivered slightly, as in the preliminary tests. The effect of the amount of salts present in Body No. 8 was probably not great enough to cause shivering to take place. Bodies 2, 5, and 9 shivered slightly, No. 5 showing a bit more of the trouble than No. 4. Bodies 3 and 6 showed a greater degree of shivering than any of the others in this series. Increasing the amount of barium carbonate used in the body, and one other change mentioned later, has entirely eliminated shivering from our body.

Shivering in white ware has been eliminated by the use of feldspar in the body, but such practice is generally out of the question with terra cotta manufacturers because of the cost. However, to investigate the properties of the feldspars and a rock having a high feldspathic content, the following tests were made.

TABLE V

1. 4 parts Clay B + 1 part ground K_2O feldspar (Maine)
2. 4 parts Clay B + 1 part ground Na_2O feldspar
3. 4 parts Clay B + 1 part ground K_2O feldspar (Colorado)
4. 4 parts Clay B + 1 part ground Felsite
5. 3 parts Clay B + 2 parts Felsite (10–40 M.)
6. 3 parts Clay B + 2 parts Felsite (150 M.)

Results.—All of the above bodies, except No. 5, were free from any indication of shivering and No. 5 was not very badly shivered. The feldspar and felsite undoubtedly acted as a flux, because the body produced was much harder and more glassy, than one made from Clay B. The feldspars or felsite in the terra cotta body have overcome all shivering action produced by the presence of Clay B or other shivering clays.

Felsite is a light greenish gray rock, not as hard but tougher than feldspar. It develops some plasticity when ground fine, and burns to a hard glassy body at cone 3. It has been used in our terra cotta body for the

last nine years. Previous to this work, it had been ground in a dry pan with the clays and grog of the body. It was then found in the body in particles about the size of grog. As shown in Bodies 5 and 6 of Table V, the finer the material is ground the more effective it is in eliminating shivering. The felsite is now ground in a separate mill before adding it to the body and the use of this finely ground material has entirely eliminated shivering. Felsite also aids in drying as it has a low drying shrinkage and does not warp in drying. The addition of too much felsite will cause warping in the firing process.

Analysis of felsite: SiO_2, 71.5%; Al_2O_3, 15.4%; Fe_2O_3, 2.0%; TiO_2, 0.5%; CaO, 0.8%; MgO, 0.4%; KNaO, 7.6%; Ign. loss, 2.1%; with a total of 100.3%.

A microscopic examination of some of the clays and bodies previously noted brings forth the following data:

Clay A (raw). Contains less free quartz than Clay B. Contains considerable mica, presumably muscovite.

Clay A (to cone 3). Body shows more glassy material than Clay B (to cone 3). Quartz not in solution.

Clay B (raw). Contains considerable free quartz and some hematite.

Clay B (to cone 3). No appreciable amount of quartz has gone into solution. Hematite still present.

Body No. 6 (Table V). Felsite has gone into solution with the clay and formed a bond around the quartz grains, which do not seem to have been taken into solution.

It was then thought advisable to make up the bodies shown in Table VI. This was done to see if the size of grog particle had any influence in causing shivering or eliminating it.

TABLE VI

	1	2	3	4
Clay A	6	6	–	–
Clay B	–	–	6	6
Grog No. 1	4	–	4	–
Grog No. 2	–	4	–	4

Grog No. 1—10–40 Mesh.
Grog No. 2—100 Mesh.

Results.—Bodies 1 and 2 did not shiver. Body No. 3 shivered slightly, while Body No. 4 was badly shivered, in fact the latter was much worse than a body containing unsized grog.

No effort has been made to check the statement that bodies high in clay substance do not shiver. However, the clays that did not shiver in the preliminary tests, were those having a high Al_2O_3 and low SiO_2 content, which would indicate that the clays were high in clay substance

and low in free silica. Whether any clay, having a similar analysis, would not shiver under identical conditions, is problematical.

The foregoing tests and results obtained would indicate that finely divided silica in the body or clay will cause shivering and that large particles, in a corresponding amount, reduce the shivering tendencies of the body and clay. We could also expect that siliceous clays, when used in a body, will undoubtedly promote or cause shivering. Fine particles of inert material, such as grog, seem to have an action corresponding to that of fine particles of silica, though to a lesser degree. Since a good many grogs used by terra cotta companies are of a siliceous nature, it is possible that only the finely ground siliceous particles have any effect. The use of sand or a sized grog (say 10–60 mesh) will tend to overcome shivering according to the results obtained in this work, but the body is made more open and porous. The writer has heard of one company who uses sand to eliminate shivering from their terra cotta body, but because the resultant body is open and porous, such practice is questionable.

Results also indicate that the use of a flux such as feldspar or felsite will overcome shivering that is caused by fine particles of silica. Whether clays, with a high feldspathic or fluxing constituent, will act in a similar manner, is a point that might be investigated. Incidentally, there are a number of rocks of the felsite type which could probably be used in a terra cotta body to overcome shivering troubles.

Clays that have become quite dense and glassy at cone 3 have shivered badly under the conditions used in this work, and likewise open burning clays have done the same. Whether the use of a flux in the body, or the use of coarse material such as sand and grog, have any effect upon the coefficient of expansion of the body, has not been determined.

The results obtained in the work covering soluble salts agreed with that of previous investigators. It is almost conclusive that soluble salts in the body will cause shivering, not to mention other troubles that can arise. However, the use of barium carbonate has been quite effective in overcoming such troubles.

Through results from experiments, it is our opinion that the thickness of the glaze coat does not seem to have any connection with shivering. We have also found that a body with a tendency to shiver is more apt to shiver when subjected to a long firing period. No investigation has been made upon this point.

Summary.—The results of this work indicate that shivering in terra cotta bodies is caused or promoted by one or more of the following:

1. The presence of a highly siliceous clay in the body.
2. The presence of considerable finely ground grog of a siliceous nature.
3. The presence of soluble salts in the clay, grog, or in the water used for tempering.

Three methods of eliminating shivering in terra cotta bodies, if caused by one of the above, are suggested by this work and that of others. They are as follows:

1. Shivering caused by the presence of siliceous material in the body may be overcome by the use of,

(*a*) feldspar, felsite, or rock having a similar composition, making the body more dense, *i. e.*, use a flux in the body;

(*b*) coarse sand or grog, making the body more open.

2. Shivering caused by soluble salts can be eliminated by the use of barium carbonate.

The writer wishes to extend his thanks to Mr. George P. Fackt for many suggestions in carrying out this work, and to Mr. Hobart N. Kraner for making the microscopic examinations.

DENVER TERRA COTTA CO.,
DENVER, COLORADO

POROSITY: VII. THE DETERMINATION OF THE POROSITY OF HIGHLY VITRIFIED BODIES[43]

By Edward W. Washburn and Elmer N. Bunting*

ABSTRACT

Design and Accuracy.—The accuracy limitations of the general laboratory research type of porosimeter are discussed and the principles of design indicated.

McLeod-Gauge Type of Porosimeter.—A new type of porosimeter is described with which the pore volume of any test piece may be directly determined within 0.01–0.02 cc.

Results with Electrical Porcelain.—Tests of eight pieces of electrical porcelain indicated a porosity of 0 ± 0.01 per cent. This result was confirmed by dye penetration tests.

An Apparatus for Measuring the Porosity of Full Size Brick.—A simple and rapid apparatus for measuring the porosity of full size brick by the "General Method" (*Jour. Amer. Ceram. Soc.*, **5**, 113–16 (1922)) is figured and described.

XX. Principles of Design

75. Accuracy Limitations of the Laboratory Research Type of Rapid Porosimeter.—Of the different laboratory types of porosimeters described in the preceding paper[44] of this series, the one described in Sec. 68 is the most accurate and convenient for general research purposes and for all cases where rapidity and high accuracy are demanded, and where standard test pieces are employed. If this apparatus is to be used for bodies of low porosity, however, certain principles of design should be adhered to and even when these principles are followed as closely as practicable there will, of course, be a limit of porosity below which measurements cannot be made with this form of apparatus. We shall therefore proceed to consider in further detail the relation between accuracy and principles of design with reference to this type of porosimeter (Cf. Sec. 67).

Instead of designing our apparatus so as to make the average total error as small as possible we shall consider the design which will make the maximum total error as small as possible. The maximum error (which will on the average occur only once in 16 times) will be produced when each of the four separate errors Δx_1, Δx_2, Δx_3, and Δx_4 (*Vide supra*, Sec. 66) happen to have the same sign. The equation expressing this maximum error is therefore given by the sum of the four equations, 21 to 24 inclusive, (Sec. 66) which express the magnitude of the separate errors.[45]

* Received May 20, 1922.

[43] Presented before the White Wares Division at the St. Louis meeting of the Society, March 1, 1922.

[44] *Jour. Amer. Ceram. Soc.*, **5**, 112 (1922).

[45] The following corrections should be made to Equations 21 to 24:

Equation 22 should read

$$\Delta X_2 = \frac{\{X[V-(R-R_0)] + 100(R-R_0)\}\,\Delta_2}{B[V-(R-R_0)]} = \frac{100+X}{1500}$$

In Equation 23, for $X\{$ read $\{X$, and for $\}^2$, read $\}^2\Delta_3$.

In writing down this sum we will, however, employ the following values for the magnitudes of the errors in the four quantities actually measured in place of the values given in connection with Equations 21 to 24; *viz.*, $\Delta_1 = \Delta_4 = 0.02$ cc. and $\Delta_2 = \Delta_3 = 0.2$ mm. In this way we obtain finally the equation,

$$\Delta X_{max} = \frac{0.02}{100 - V_F}\left[X + \frac{X(100 - V_F) + 100V_F}{75} + \frac{[X(100 - V_F) + 100V_F]^2}{7500V_F} + \frac{100X}{V_F}\right] \quad (26)$$

This equation is for a porosity bulb with a total volume of about 100 cc. and a free volume, V_F cc. ($= 100 - V_B$ cc., where V_B is the bulk volume of the test piece).

In Fig. 12 are shown the graphs of this equation for different values of x. It is evident from this figure that for each value of x there is a "best value" for V_F, that is, a value which gives the smallest maximum error. The heavy parabolic curve is the locus of these "best values." It is clear from this figure that, if this best value for V_F could be realized in each measurement, a very high degree of accuracy could be attained. It is scarcely feasible, however, to make V_F lower than about 30 cc. and if a single piece of apparatus is to serve for all types of bodies, both raw and fired, and for test pieces which are made in one standard sized mold (*e. g.*, $1 \times 1 \times 4''$) values of V_F as large as 70 cc. will be encountered. Even with such a value for V_F, however it is evident from Fig. 12 that the accuracy attained is quite ample for all the various types of bodies except those of very low porosity. Thus even for $x = 1\%$ we find Δx_{max} = about 0.1%. This could, of course, be reduced to 0.03% by using a test piece of 70 cc. volume (*i. e.*, $V_F = 30$ cc.) but for cases where Δx_{max} should be less than 0.1% it is more convenient to use another type of apparatus which will now be described.

XXI. The McLeod-Gauge Type of Porosimeter

76. Advantages and Disadvantages.—This type of porosimeter is shown in Fig. 13 and in Fig. 14 Y. Only a single reading is required in determining the pore volume of the test piece and a test piece of any size and any shape and of any porosity may be employed, the only condition being that the pore volume of the test piece must not exceed the capacity of the measuring tube of the apparatus. The capacity of this tube may, however, be made as large as desired. This type of porosimeter measures only the pore volume. The bulk volume must be separately determined in a mercury volumeter. The laboratory research type of porosimeter (Fig. 14 N) may be conveniently employed as such a volumeter since it is both rapid and accurate.

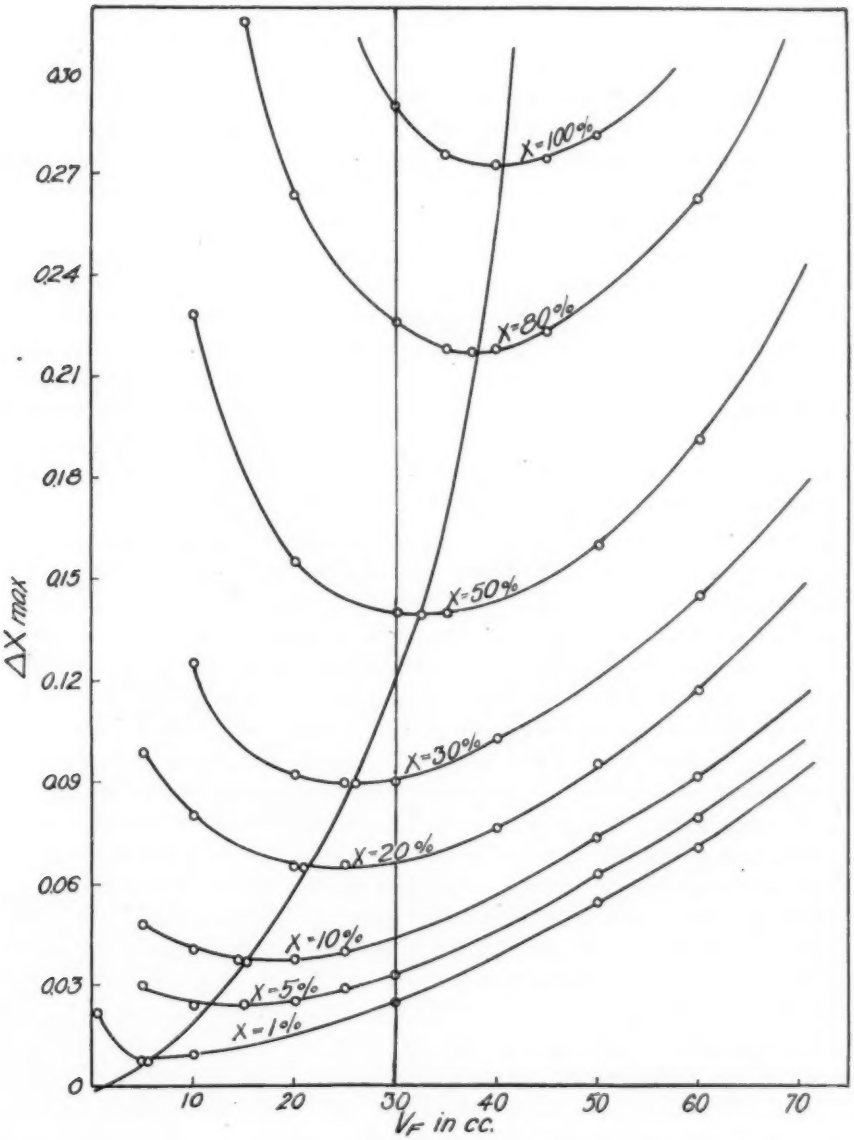

0.30
0.27
0.24
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0
ΔX max
10
20
30
40
50
60
70
V_F in cc.
X=100%
X=80%
X=50%
X=30%
X=20%
X=10%
X=5%
X=1%

FIG. 12.

The McLeod-Gauge type of apparatus will probably find its chief use in measuring the porosity of highly vitrified bodies because of the great accuracy which can be attained. This accuracy is about 0.01 cc. on the pore volume and is independent of the size and porosity of the test piece employed. The apparatus will thus be found convenient for measuring the pore volume of small pieces of porous materials of any degree of porosity since a test piece of standard size is not necessary in order to obtain accurate results with this apparatus. The reason for this is, of course, the fact that with this apparatus errors in measuring the bulk volume do not affect the accuracy of the pore volume determination.

77. Operating Procedure.—(1) Set up and connect the apparatus as shown in the photograph, Fig. 14 Y. (2) Pour 250 cc. of mercury into the leveling bulb. (3) Open stop-cock and raise leveling bulb until the apparatus is filled with mercury to a short distance above the stop-cock. (4) Close stop-cock and lower leveling bulb until mercury falls to the bottom of the porosity tube stem. (5) Raise leveling bulb to level of bottom of porosity tube and clamp it in its support. (6) Open stop-cock and when the mercury has fallen to equilibrium, release rubber bands, open the apparatus, insert the reference test piece, put the apparatus together, and again fasten it in place with the rubber bands. (7) Pour some mercury into the mercury seal. (8) Raise the leveling bulb until the apparatus fills with mercury as before. (9) Close stop-cock and lower leveling bulb until the mercury falls below the bottom of the piece. (10) Raise leveling bulb to level of stop-cock and when the mercury in the apparatus has come to rest, open the stop-cock, thus expelling the gas from the capillary tube. (11) Close stop-cock and lower the leveling bulb to the level of the bottom of the test piece. (12) Open stop-cock slightly and allow the apparatus to fill slowly with dry air. (13) Allow the test piece to soak in the dry air until equilibrium is attained. (14) Again raise the leveling bulb until the apparatus fills with mercury, close the stop-cock and lower the leveling bulb until the mercury drops below the bottom of the test piece. (15) Allow the test piece to soak *in vacuo* until equilibrium is attained. (16) Raise the leveling bulb until the two mercury surfaces are on the same level and read the volume of air in the graduated capillary tube. (17) Lower the leveling bulb to the level of the bottom of the test piece and open stop-cock. (18) Remove the reference test piece and replace by a test piece. (19) Repeat operations 7 to 17 inclusive. (20) Subtract reading obtained with the reference test piece from the reading obtained with the test piece, the difference is the pore volume, V_P, of the test piece. (21) Determine the bulk volume, V_B, of the test piece, using the apparatus shown in Fig. 16 N, or any accurate mercury volumeter.

The portion of the above procedure which is carried out with the reference test piece in place, *needs to be done only once for a given apparatus,*

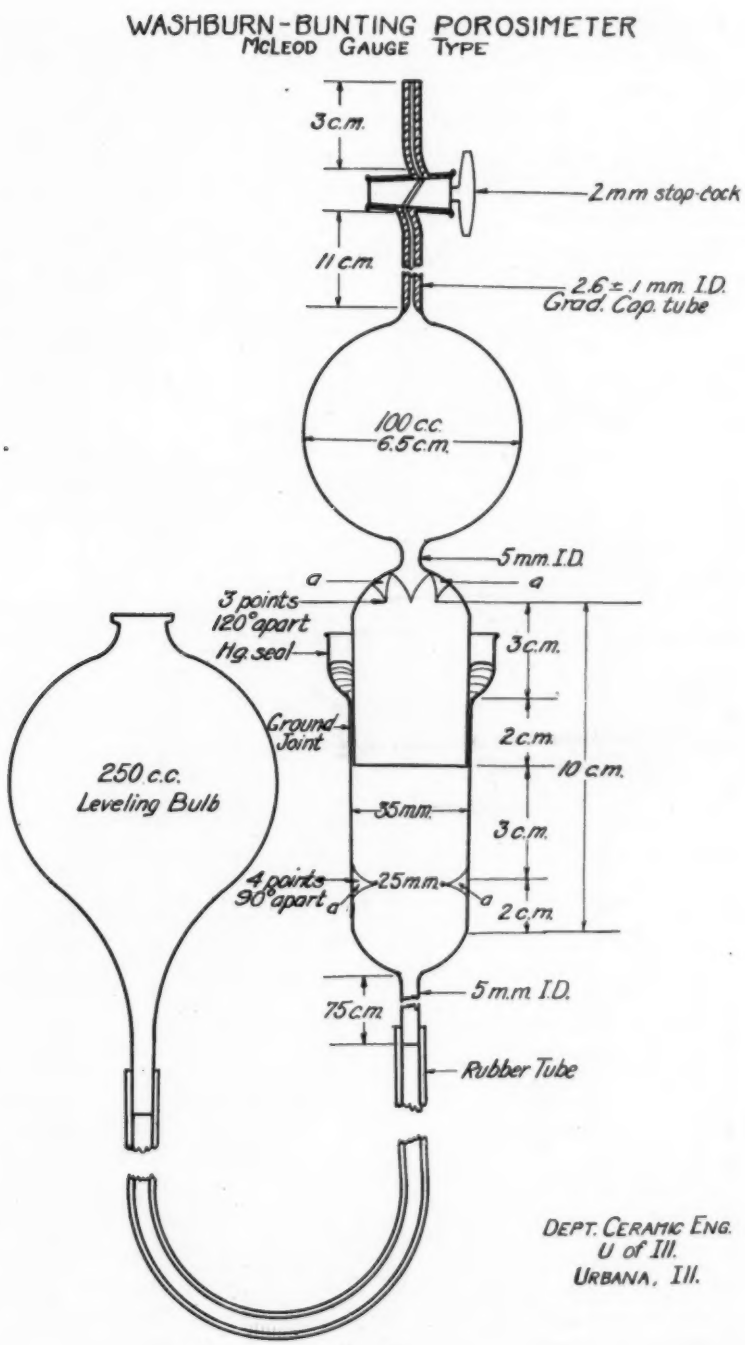

WASHBURN-BUNTING POROSIMETER
McLEOD GAUGE TYPE
3 c.m.
2 mm stop-cock
11 c.m.
2.6 ± .1 mm. I.D.
Grad. Cap. tube
100 c.c.
6.5 c.m.
5 mm. I.D.
a
a
3 points
120° apart
Hg. seal
3 c.m.
Ground
Joint
2 c.m.
10 c.m.
250 c.c.
Leveling Bulb
35 mm.
3 c.m.
4 points
90° apart
25 m.m.
a
a
2 c.m.
5 m.m. I.D.
75 c.m.
Rubber Tube
DEPT. CERAMIC ENG.
U of Ill.
URBANA, Ill.

FIG. 13.

as the reading thus obtained is a constant for a given apparatus and a given size of test piece. As shown by the results given below the accuracy obtainable is 0.01 to 0.02 cc. on the pore volume. The bulk volume of the reference test piece should be approximately the same as that of the test piece itself, and the surface of the reference test piece and of the test pieces themselves should be approximately smooth and free from cracks, pits and other irregularities liable to retain enclosed air.

78. Calculation of the Porosity.—The per cent porosity, x, is calculated directly from the relation

$$x = \frac{100 V_P}{V_B} \tag{27}$$

The use of this simple equation is justified provided the apparatus is constructed so as to fulfill the following condition

$$\frac{V_c^2}{V_F} \gtrless 0.01 \text{ cc.} \tag{28}$$

Where V_c is the volume of the measuring tube and V_F is the total free volume of the apparatus when it contains the test piece.

79. Test Experiments with Electrical Porcelain.—Table X shows the character of the results obtained with (*a*) a glass test piece and (*b*) eight standard pieces of electrical porcelain. The results in column 1 show that if dry air is not employed the error due to adsorbed moisture is about 0.02 cc. The agreement between columns 2 and 3 shows that a 15-minute soaking *in vacuo* is ample. The result in column 2 in the case of

TABLE X

BEHAVIOR OF ELECTRICAL PORCELAIN IN THE MCLEOD-GAUGE TYPE OF POROSIMETER

The test pieces were supplied by the General Electric Company and were of standard size (ca. 1 × 1 × 4″)

Body	Nature of Surface	Cc. of gas obtained 1	2	3
Glass 1	Highly polished	0.09	0.07	0.07
Glass 1	Ground-glass	.16	.14	.14
P.1	As received	.15	.14	.14
P.1	Polished on fine emery wheel	.12	.11	.11
P.2	As received	.16	.14	.14
P.3	As received	.15	.14	.14
P.4	As received	.15	.14	.14
P.4	Slightly polished	.14	.13	.13
P.5	As received	.16	.15	.15
P.6	As received	.15	.14	.14
P.7	As received	.17	.15	.15
P.7	Polished on fine emery wheel	.13	.12	.12
P.8	As received	.15	.13	.13

[1] Result obtained using air from the room.

[2] Result obtained with dry air after allowing piece to soak 15 min. *in vacuo*.

[3] Result obtained with dry air after allowing piece to soak 1 hr. *in vacuo*.

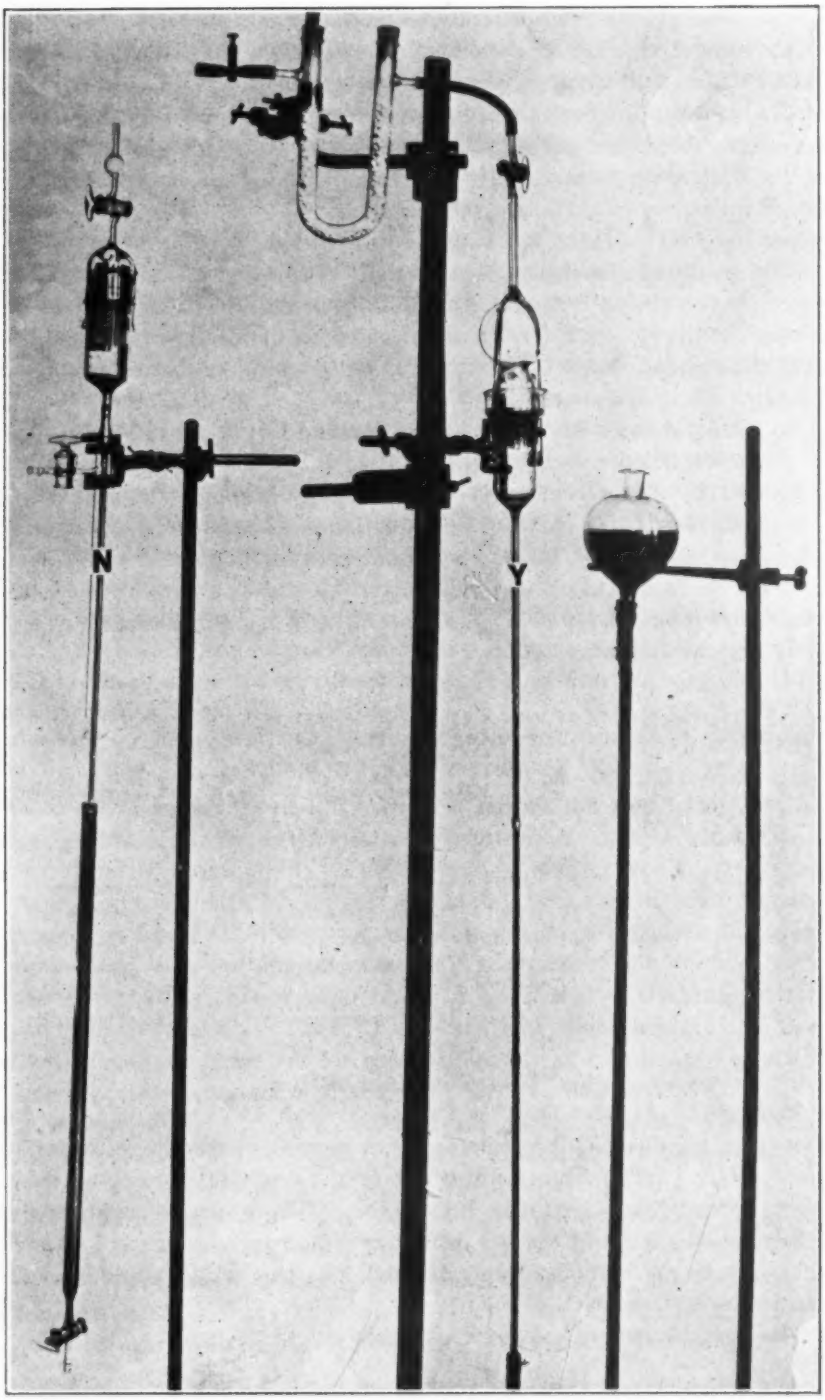


FIG. 14.

the polished glass test piece represents adsorbed air plus the air entrapped at the ground joint and at the points where the test piece touches the apparatus. This is a constant quantity.

The increase obtained when the glass test piece is given a rough surface represents the surface porosity which is also a constant for a given piece, and as the data show, is practically the same for the ground glass and for the porcelain pieces in their natural condition. Polishing the surface of the porcelain pieces naturally diminishes this surface porosity.

The results obtained show further that, within the constancy of the surface porosity (0.01–0.02 cc.), the bulk porosity of all of the porcelain pieces examined is zero. A piece of electrical porcelain of zero porosity may thus be conveniently used as a reference test piece for any of the various types of porosimeters.

80. Comparison with Water Absorption and Dye Penetration Methods.—The electrical porcelain test pieces used in the above experiments were furnished by the General Electric Company through the courtesy of Mr. L. E. Barringer. After the completion of our tests with these pieces, they were returned to Mr. Barringer and were further tested in his laboratory by the standard methods employed by the Company. These tests were carried out under the supervision of Mr. C. C. Treischel and he has given us the following report.

TABLE XI

POROSITY OF ELECTRICAL PORCELAIN TEST PIECES AS DETERMINED BY WATER ABSORPTION AND DYE PENETRATION

No.	Water absorption	Dye penetration 250 lbs. per sq. in. 12 hours	Dye penetration 7000 lbs. per sq. in. 12 hours
P.1	0.09	No penetration	No penetration
P.2	.09	No penetration	No penetration
P.3	.09	No penetration	No penetration
P.4	.25	No penetration	No penetration
P.5	.11	No penetration	No penetration
P.6	.08	No penetration	No penetration
P.7	.31	No penetration	No penetration
P.8	.09	No penetration	No penetration

The water absorption test was made as follows:

The briquettes were first dried in an oven at 120°C for 12 hours and were then weighed. After weighing they were immersed in water for 100 hours, boiling for one hour during the first, twenty-fifth, forty-ninth and seventy-third hours. At the end of the 100-hour period samples were dried and weighed and the per cent water absorption calculated from the difference between the wet and dry weights (this is our standard water absorption test at the General Electric Co.)

The dye absorption tests were as follows:

The briquettes were broken in quarters and one-quarter of each was used for the test at 250 lbs. per square inch and the second quarter was used for the test at 7000 lbs. per square inch. The dye solution was fuchsine dissolved in alcohol. The length of time during which the pressure was applied was 12 hours in each case (the 250 lb. dye test is standard with the General Electric Co., while the 7000 lbs. dye test is standard with the Locke Insulator Corporation).

With reference to the water absorption test we consider as non-porous any porcelain showing less than 0.25 per cent absorption.

It will be noted that the results of the dye penetration method, even under pressures of 7000 lbs. per square inch, agree with the results obtained with our porosimeter in indicating zero porosity for all the samples studied. The results reported on the water absorption tests are difficult to explain. They can scarcely represent any actual porosity since the other two far more sensitive methods failed to show any pore space. In the endeavor to find an explanation for the water absorption results reported by Mr. Treischel we boiled steadily for 50 hours a broken 80 gram test piece from the original lot and after drying with a cloth and weighing (to 0.1 mg.), it showed *no appreciable gain in weight.*

As the net result of the above experiments it seems justifiable to conclude that the McLeod-Gauge type of porosimeter may be recommended for the accurate and rapid measurement of the open-pore porosity of highly vitrified bodies.

XXII. Appendix

81. The "General Method" for Full Sized Brick.—A convenient apparatus for determining the porosity of full sized brick by the *General Method*[46] is shown in Fig. 15. The containing vessel is designed to take the largest size standard brick in the dry state. For smaller brick the unoccupied space may be filled as explained in Sec. 55, using glass plates for this purpose. The containing vessel may be made of any suitable non-porous material (*e. g.*, glass, metal, porcelain). The cover is a glass, metal, or porcelain plate ground so as to give an air-tight joint when greased, this method of closure being similar to that used in the ordinary chemist's desiccator. The remainder of the apparatus is mounted permanently on the cover and is easily constructed from glass tubing and a distilling flask. An ordinary water-jet suction pump is satisfactory for evacuating the flask.

The operating procedure is as follows: (1) With the brick in place, and both stop-cocks open, read the manometer, (*i. e.*, the difference in the two mercury levels), B. (2) Close stop-cock 1 and evacuate the flask F to some low pressure, P_1. (3) Close stop-cock 2 and again read the man-

[46] See the 6th paper of this series, *Jour. Amer. Ceram. Soc.*, **5**, 113–116 (1922).

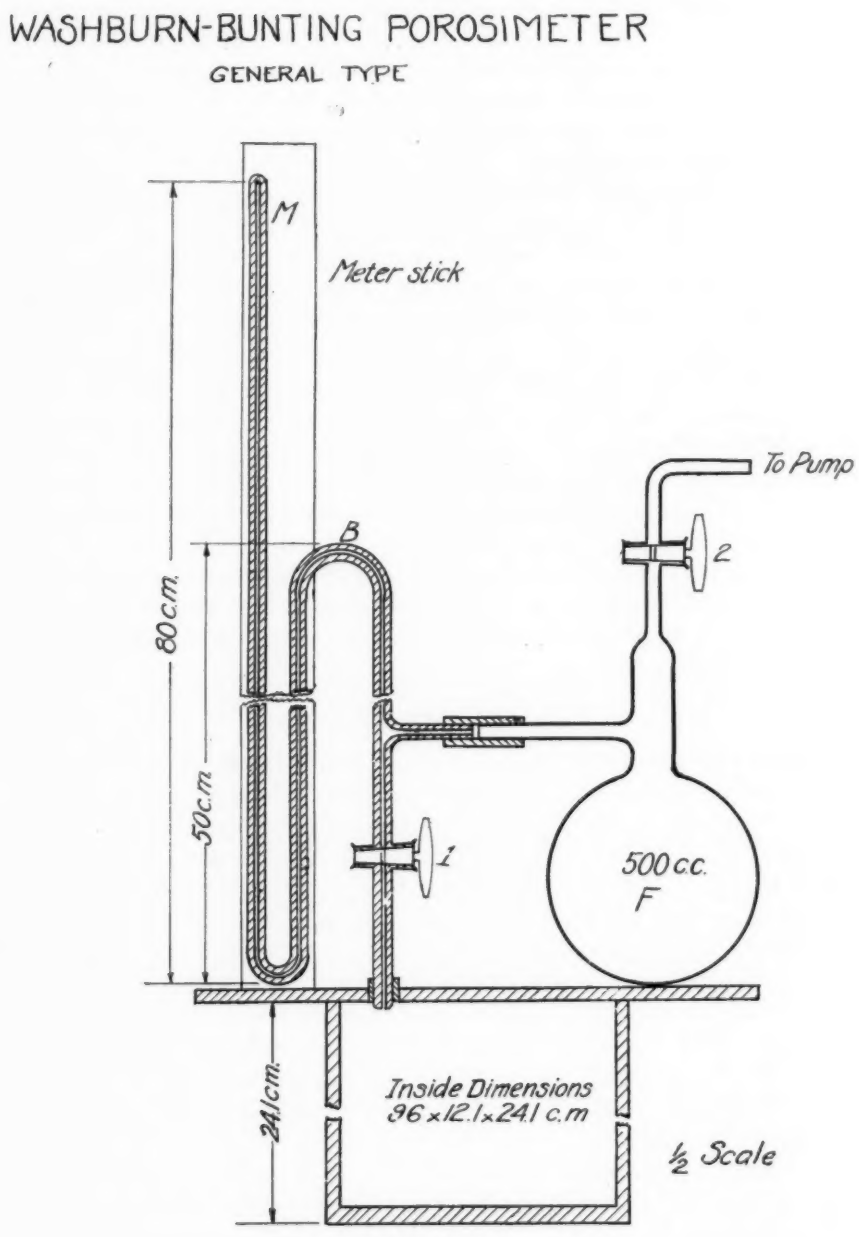

WASHBURN-BUNTING POROSIMETER
GENERAL TYPE
M
Meter stick
B
To Pump
2
80 c.m.
50 c.m.
1
500 c.c.
F
24 c.m.
Inside Dimensions
9.6 x 12.1 x 24.1 c.m
½ Scale

FIG. 15.

ometer, P_1. (4) Open stop-cock 1 and when pressure equilibrium is attained, again read the manometer, P_2. (5) Calculate the per cent porosity, x_1

$$x = 100\left[\frac{(P_2-P_1)V_1}{(B-P_2)V_B} - \frac{(V-V_g-V_B)}{V_B}\right] \tag{29}$$

where V_1 is the volume of the flask F from stop-cock 2 around to stop-cock 1 and including that portion of the manometer tube from the mercury surface in B around to the side-arm leading to the flask; V is the volume of the containing vessel and that portion of the capillary up to stop-cock 1; V_g is the volume of any glass plates which may be used for reducing the free volume of the containing vessel. (Cf. Equation 14, Sec. 55.) The bulk volume, V_B, of the brick may be conveniently determined with a water volumeter of the over-flow type, the brick being first dipped momentarily into hot paraffine or rubbed thoroughly with vaseline or other similar grease, in order to close its surface pores. With unperforated bricks having straight edges the bulk volume may in most cases be computed with sufficient accuracy from the linear dimensions.

SOLUBLE SALTS AND CLAY WARES*

By Cullen W. Parmelee†

ABSTRACT

A résumé of the present knowledge of the causes and the prevention of "Scum" and "Efflorescence." It is proposed that the term "Efflorescence" be restricted to designate the surface deposits appearing because of the presence of soluble salts in the clays or burned wares and that the term "Scum" be used to describe the salts formed by the action of gases upon the wares during the drying or burning operations.

Mention is made of the formation of a surface coating upon the ware soon after the kiln is opened, sometimes not appearing until some days after the ware is removed from the kiln. This scum is readily and permanently removed by the application of water.

Such a residue was found to consist of sodium sulfate and sodium chloride. It is suggested that its formation was due to the presence of sodium chloride in the fuel and its subsequent deposition on the burned ware where it was changed in part to the sulfate by the action of the oxides of sulfur evolved from the fuel.

Introduction.—The causes and the cures for the various manifestations of these salts have been topics of lively interest among manufacturers, architects and builders for many years. A very considerable amount of literature has been accumulated which has furnished a valuable source of information. In fact, the writer feels some hesitancy in presenting this paper because he recognizes the fact that most phases of the subject have been so ably discussed by others that this cannot be considered an original contribution, but a compilation of various opinions. However, I have been surprised to find that one phase of the subject which is of considerable inportance has scarcely been noticed by writers; namely, the type of kiln scum which is of temporary character as contrasted with that which appears to be permanently burned into the ware.

Definitions.—In order to clear our way of misunderstandings due to a confusion in the use of terms, I will define those which I am about to discuss. They are: *Efflorescence:* The accumulation of salts upon the surface where they have been brought in solution and deposited upon the evaporation of the water. *Scum:* A term which is used interchangeably with efflorescence.

There does not appear to be any general agreement as to a distinction in the usages of these terms. Searle, an English writer, author of several books on ceramic topics, says that "efflorescence" is due to the formation of this deposit during drying and that "scum" is formed during the burning. In answer to an inquiry made by letter, one of your members has kindly written to me that in his study of the matter he has found the

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term efflorescence applied to the discoloration which appears on the brick in the wall, or brick in stock piles after they have been wetted. "Scum," he says, is commonly understood by himself and his associates to be the surface deposit which is formed during the drying process.

Dr. H. Ries, in his book "Building Stones and Clay Products,"[1] uses both terms without differentiating between them. Lovejoy,[2] in an article entitled "The Use of Barium Compounds in Preventing Scum," says that there are "three distinct lines of efflorescence," one of which is "dry-house white, the common scum." In other words his practice conforms to that mentioned by one of your members. A diligent search of literature has failed thus far to find any general agreement regarding the use of the terms.

It is well for us to arrive at some agreement regarding the use of these terms since it is obvious that we cannot hope to make much progress in a discussion, if each party is using a different language.

My own feeling in the matter is that we can use the word "efflorescence" as defined in the dictionary to include all surface deposits of salts which have accumulated there through the agency of water which has brought them to the surface in solution. This term will then include those surface deposits of salts that accumulate upon raw clays in their original beds, or in stock piles and bins, all surface deposits which occur in the drying of the ware *excepting* certain examples dried with the waste heat of burning kilns, all coatings of soluble salts on masonry work in walls, piers, etc., which have originated through the solvent action of water upon materials in the clay wares or have been contributed by the mortar used, also coatings of soluble salts brought to the surface during the early stage (the water smoking) of the burning process.

The use of the word "scum" I would limit to designate all surface coatings of soluble salts which have originated through the agency of gases in the atmosphere of the drier or kiln; also through deposits upon the surface of volatile substances. Our classification will then include:

Efflorescence	Soluble salts upon clays
	Drier or dry-house white
	Kiln white—certain forms
	Wall white
Scum	Drier white due to the action of waste gases
	Kiln white with exception noted above
	Certain forms of wall white

We will now take up these items in detail discussing the causes, occurrence and proposed remedies.

[1] Ries, "Building Stones and Clay Products," p. 312.

[2] Lovejoy, *Trans. Amer. Ceram. Soc.*, **8**, 255 (1906).

Efflorescence

On Raw Clays.—All clays contain soluble salts. That is to be expected since all clays have been formed through processes of decomposition and solution of various rocks, many of which are of types very resistant to chemical attack. English china clays which have been formed from rocks of a granitic type and are typical of the purest kind contain, according to Dr. Mellor,[1] about 0.015 per cent soluble salts. The same authority says that ball clays contain normally 0.4% soluble salts which are chiefly soluble silicic acid (15 to 20%) and soluble silicates of alkalies and alkaline earths with about 1 to 2% of alkaline chlorides and about 20% of sulfates. Ries, in his report upon the clays of New Jersey, found in testing a large number of samples which varied widely in character that the soluble salts ranged from 1.49% to nothing. The report on the clays of West Virginia by Grout states that the amount of soluble salts present varied from a trace to 1.2%. In a report on the clays of Texas,[2] Dr. Ries states that the amount of soluble salts ranged from 0.05 to 1.21 per cent.

Fortunately, the soluble salts are not all objectionable and also certain conditions interfere to prevent the objectionable ones from always exerting the maximum harmful influence.

Character.—The soluble salts present in clays are of many sorts. They include hydrated silicic acid, aluminum salts, probably most commonly the sulfate, the sulfate of iron (the writer has seen crystals of both the sulfates of iron and alumina upon the face of clay as it lay in the bank), the sulfates of lime, magnesium, and the alkalies, sodium and potassium, also the chloride of sodium is not infrequently found and it is altogether probable that this list may be very considerably extended. Of these salts, the most frequently found and the most troublesome are the sulfates of lime and magnesia.

Formation.—In studying clays, we are dealing with materials which contain particles of varying sizes, some of which are so small that they cannot be seen except with a microscope especially designed for the purpose. When matter is reduced to such infinitesimally small fractions and subjected to prolonged contact with water, it is taken into solution, more or less. This process is repeatedly occurring in our laboratory work. When we grind material for a long period in contact with water, we find that there is unmistakable evidence of a gradual solution of a small portion of the batch. Therefore, we expect to find soluble salts in all clays, varying in amount and character of course, but there, nevertheless, because of the continued solution of the finest portions upon long

[1] Mellor, "Clay and Pottery Industries," p. 56.

[2] Ries, *Bull. Univ. Texas*, No. **102**, p. 45.

contact with water. This is the explanation for the observation of Grimsley and Grout[1] that the soluble salts found in West Virginia clays were unexpectedly high in alumina and silica and in some cases no sulfates could be found.

In fact, the determination of the amount of soluble salts in clays is seriously complicated by the progressive solubility of clay in contact with water, so that the duration of the contact and the temperature are extremely important factors in such an investigation. You will find this point noted in a paper which was contributed to the *Transactions of the American Ceramic Society.*[2]

Formation of Sulfates.—Iron pyrites (ferric sulfide) is a common mineral in almost all kinds of clays, occurring in large lumps and also in finely divided particles. It is quite insoluble. If this mineral, especially the form known as marcasite, is exposed to free contact with air and moisture, it will oxidize to form the sulfate of iron which dissolves freely in water and is frequently found as a yellow or brownish yellow efflorescence on raw clay which has a sweetish astringent taste, reminding one of ink. This efflorescence sometimes occurs on ware coming from the drier and is known as "brown scum." On the burned ware, *i. e.*, of red or brown color, it cannot be readily distinguished, because it is decomposed during the burning and the iron oxide remaining will be red or brown.

The sulfate of iron formed from the pyrites in the clay will decompose quite readily and set free sulfuric acid which in turn will speedily attack the carbonates of lime, magnesia or iron which may be present and form the sulfates of these bases. This is a very ordinary method of the formation of the sulfates of lime and magnesia.

For this reason, the weathering of clays containing pyrites or marcasite, the sulfides of iron, has been a frequent cause of serious efflorescence. The remedies are either, use the clay as promptly as possible after mining, or on the other hand weather the clay for a sufficient length of time to permit the complete change and removal of the sulfides. However, this will not avail if the clay contains the carbonates of lime, magnesia or iron, since the sulfuric acid formed will attack and form the very troublesome sulfates of these bases.

Ries[3] cites the analysis of a clay freshly mined containing pyrites which showed a soluble salt content of 0.2 per cent. The same clay which had weathered showed 0.87 per cent soluble salts.

If weathering is resorted to, the clay should be spread out in a layer not over two feet thick on a hard, slightly inclined floor. This will permit the removal by natural drainage of the soluble iron salts formed. Of

[1] Grimsley and Grout, *West Virginia Geol. Surv.*, Vol. III, p. 26.

[2] *Trans. Amer. Ceram. Soc.*, **11**, 467 (1909).

[3] Ries, "The Clays of Texas," *Bull. Univ. Texas*, p. 45.

course, the weathering process may be hastened by spreading the clay in thinner layers and by wetting the mass thoroughly from time to time.

In this process, the soluble salts formed are brought to the surface during drying and then removed by the water which falls upon the surface, either as rain or from a hose. Analyses which I have before me showing the change in a clay by weathering gives the following figures:

	Before weathering	After weathering
Lime (CaO).....	1.98%	1.01%
Alkalies (Na_2O, K_2O).....	1.62%	0.75%

This illustrates how the change proceeds in that particular case.

Mellor[1] suggests that soluble salts in a clay may be due to the action of humic acid upon calcium carbonate which is present. Humic acid is one of the products formed by the decomposition of organic matter and, undoubtedly, it is a common constituent of many clays.

Amount of Soluble Salts.—The amount of soluble salts which may be permissible in a raw clay or shale without danger of efflorescence is not known. According to Ries[2] less than 0.1% is often sufficient to produce a white incrustation. Searle[3] says that as little as 0.01% of the sulfates of lime, magnesia, alkalies, ferrous iron and aluminum has been known to spoil facing brick. Dr. Mackler[4] is quoted as saying that "the amount of scum formed on finished goods bears no definite relation to the proportion of soluble salts contained; but there is quite a definite relation between the amount of the magnesium and sodium sulfates and that of scum." There are other factors involved concerning which we will speak further on.

Staley[5] has made an exceedingly interesting observation. He added calcium sulfate to a fine grained red burning shale in amounts increasing to 3% of the dry clay and was unable to produce efflorescence even with slow drying. When he added 1% of magnesium sulfate it appeared in large quantities and a 1% mixture of equal parts of the sulfates of calcium and magnesium gave an even greater amount of efflorescence. He explains this by pointing out that magnesium sulfate is very soluble in water while calcium sulfate has only a slight solubility. He also states that small amounts of calcium sulfate hastened the rate of drying which would act towards a decrease in efflorescence.

Barringer[6] experimented with a fireclay by adding increasing amounts of calcium sulfate and magnesium sulfate in the ratio of 3 to 1. Ad-

[1] Mellor, "Clay and Pottery Industries," p. 56.
[2] Ries, "Clays, Their Occurrence, Properties and Uses," p. 116.
[3] Searle, "Clayworkers' Handbook," p. 335.
[4] Mackler, *Ibid.*, p. 243.
[5] Staley, *Trans. Amer. Ceram. Soc.*, **17**, 200 (1915).
[6] Barringer, *Ibid.*, **4**, 224 (1902).

ditions of these salts up to 3% did not show a corresponding increase in efflorescence.

Determination of Soluble Salts.—Those interested in the procedure used in the determination of soluble salts are referred to the following literature:

Mellor, "Quantitative Inorganic Analysis," p. 630.
Mellor, "Clay and Pottery Industries," p. 53.
Grout, *West Va. Geol. Sur.*, III (1905), p. 26.
Ries, *New Jersey Geol. Sur.*, VI (1905), p. 76.
Ashley, *Bur. of Standards Tech. Paper* **23**, p. 96.
Bleininger, "Electrical Conductivity of Clays." *Trans. Amer. Ceram. Soc.*, **15**, p. 523.

Determination of Soluble Sulfates (Factory Method).—A factory method for the determination of the soluble sulfates which is simple in operation and requires very little apparatus is as follows:

Into each of several glass jars, the pint size fruit jar or a jelly tumbler will do, there are weighed equal quantities of the clay which have been dried previously at the temperature of boiling water. To these various jars equal quantities of distilled water are added and the samples are well stirred or agitated. If distilled water cannot be obtained, the water from condensed steam may be used or even rain water which has been gathered in clean receptacles after the first downfall has washed the air free from acid gases. In the vicinity of large towns or manufacturing plants, it is inadvisable to collect rain water for such a purpose. A dilute solution of a known strength of barium chloride is carefully prepared with distilled water. Into one of these several samples of clay is introduced a measured quantity of the barium chloride solution. To another sample is added a slightly larger quantity and so on gradually increasing the amounts of the barium chloride used. After stirring or agitating each sample thoroughly, they are allowed to stand for several hours in order that the clay may settle as much as possible. A small portion of the clear or slightly turbid water is carefully poured off from each jar. If turbid, it will be necessary to run these portions through filter paper and even boil them with the addition of a small amount of hydrochloric acid, or, as has been recommended, a solution of aluminum chloride. After a portion of the fluid has been removed from a sample and clarified, a drop or two of dilute sulfuric acid is added and the appearance of the fluid noted. If a white cloud forms upon the contact of the drop of acid, it is an indication of the presence of an excess of the barium chloride. Since the barium chloride which was added to the various portions has had an opportunity to react with the sulfates and to render them all or most of them insoluble, depending upon the quantity of the sulfates or sulfuric acid present, the presence of an excess of the barium chloride indicates that more than a sufficient amount of the barium chloride has been added

to do the work for which it was intended, namely, to render the sulfuric acid and sulfates insoluble and therefore harmless. We will assume, by the way of an example, that the first five sample jars do not show any appearance of a white cloud or precipitate upon the addition of the drop of dilute sulfuric acid, but that the sixth jar does show this appearance. The sixth jar therefore contains an excess of the barium chloride. Since we know the weight of clay in the jar and the amount of barium chloride added to it, we are in possession of the necessary data for the calculation of the amount of barium chloride or barium carbonate which is required for addition to any known weight of the dry clay.[1]

Water as a Source of Soluble Salts.—It not infrequently happens that the water used in the manufacture of wares is the cause of the appearance of efflorescence. It should always be considered in the investigation of the cause. Very frequently information regarding the local supply may be had through some State Bureau, such as our own Water Survey.

If the water supply is contaminated by waste from factories, drainage from mines or town sewage, trouble may follow. Unfortunately, definite information regarding the relation between the condition of the water and the appearance of soluble salts is not available.

Prevention.—It has been stated that weathering for a limited period may cause or aggravate the trouble while long-continued thorough weathering will prevent the difficulty by dissolving and removing the salts. For a similar reason the elaborate process of washing clay, such as used by potters, affords an excellent means for removing soluble salts. This, however, is too expensive for brickmaking.

The method of prevention most commonly employed is the addition of some compound of barium to the clay. The principle which lies at the basis of this practice, is to convert the sulfates of lime and magnesia into less soluble salts. The relative solubilities[2] are as follows:

One part of	Parts of water
Calcium sulfate	495.0
Magnesium sulfate	3.75
Barium carbonate	45,450.00
Barium sulfate	435,000.00
Calcium carbonate	77,000.00
Magnesium carbonate	9,400.00

If we add barium carbonate to a solution of calcium sulfate we immediately initiate a chemical reaction which gives as final products barium sulfate and calcium carbonate. An inspection of the above table will show that both the calcium carbonate and the barium sulfate are far less soluble than the original salts. The same is true of the magnesium car-

[1] Detailed information regarding this test has been frequently printed, but will be gladly supplied by the author to any interested party.

[2] Staley, *Trans. Amer. Ceram. Soc.*, **17**, 201 (1915).

bonate which will be formed in a like manner. Therefore, this procedure is a sound one in theory as well as in practice.

There are some variations which should be noted. One is the use of barium chloride for part of the barium carbonate. This is a very readily soluble salt which is of advantage since it may be more uniformly and intimately distributed throughout the clay mass whereas the slight solubility of the barium carbonate limits the speed of its action, and longer time is required for it to act effectively.

The very solubility of the barium chloride necessitates caution in its use because an excess over that actually required may be accompanied by the appearance of the barium chloride as an efflorescent salt. The best and usual practice is to add nearly the required amount of barium chloride and enough of the barium carbonate to take care of the last remnant of soluble salts. A reasonable excess of barium carbonate will be unobjectionable.

In recent years, the use of barium fluoride has been proposed as a desirable substitute for the barium carbonate and barium chloride. It is soluble in 614 parts of water and therefore is much more soluble than the carbonate and consequently it is more efficient. It is much less soluble than the chloride. Therefore, an excess will be less dangerous. According to Mr. Staley, who recommended it, it has no deleterious effect upon the color of the burned ware and it promotes vitrification.

Method of Introducing the Barium Salts.—The most rational and most efficient method is to provide a suitable tank with a stirrer in which the barium salts may be dissolved or suspended in water. Keep this mixture constantly agitated and feed regularly and uniformly into the clay mix.

Amount of Reagent.—The amount of barium carbonate to be added is commonly in large excess of the theoretical quantity. In fact, we find instructions in text-books to the effect that the amount should be ten times the calculated theoretical quantity. Undoubtedly an excess is ordinarily needed since the barium carbonate has such a low solubility that it must be generously distributed in the clay batch in order to be reasonably effective within the limited time for action. It is not good practice to use amounts in large excess, however, since thereby the costs are increased and further the color[1] of the brick may be lightened or impaired. One[2] experimenter has noted that in several trials he did not find it necessary to use an excess of the reagents.

Seger[3] directs that twice the theoretical quantity of barium carbonate be used.

[1] Staley, *Trans. Amer. Ceram. Soc.*, **17,** 202 (1915); Layman, *Ibid.*, **18,** 265 (1916).
[2] Staley, *Ibid.*, **17,** 202 (1915).
[3] Kerl, Cramer and Hecht, "Abriss Tonwaarenindustrie," p. 523 (1907).

Owing to the low solubility of the barium fluoride, an excess of it is not to be feared and as previously stated it does no harm to the color of the ware.

The Use of Common Salt and Carbonate of Soda.—The use of small amounts of common salt and soda ash (*i. e.*, sodium carbonate) has been proposed and interesting results have been reported.[1] Additions of these chemicals in amounts up to two per cent increased the amount of the efflorescence in the drying, but there was none on the burned ware. One clay which normally showed a heavy scum when burned, showed progressively decreasing amounts of the scum as the amount of these chemicals was increased. Mr. Staley, who has reported these results, is of the opinion that the heavy deposits of the common salt and the sodium carbonate which came to the surface during the drying served to volatilize or flux the normal scum. He says, further, that the effect of the sodium carbonate slightly darkened the color and the sodium chloride produced a brighter, clearer color. It is desirable that further investigation of the use of the salts and other chemicals should be made on a variety of shales and clays in order that we may know more about the possibilities of what appears to be a very promising procedure.

Drier White.—This is an efflorescence which appears during the drying period. The causes are:

(1) The use of the gases of burning kilns (scumming).
(2) The presence of soluble salts in the clay.
(3) The presence of soluble salts in the water used in the manufacture of the ware.

The harmful effect of the waste gases of burning kilns upon damp ware is so well understood that only a few words should suffice to emphasize the necessity for avoiding the practice. Such waste gases from burning coal, gas or oil will contain more or less of the oxides of sulfur. These gases (sulfur dioxide and sulfur trioxide) will combine with the water present on and in the ware and form strong acids which react very promptly with the carbonates of lime and magnesia and with any alkali salts which are present in a form which is readily attacked. The products of such reactions are the sulfates which form the efflorescence on the unburned ware. Therefore, this method of drying is suited only for wares which are not harmed by the formation of the efflorescence.

The character of the soluble salts which are in clays and in the water which is used has already been discussed. It is the movement of these soluble salts in the clay ware during the drying which is now our concern. The factors which influence the appearance of the efflorescence are:

(1) The degree of solubility of the compound present.
(2) The amount and the size of the particle of the soluble salt present.
(3) Temperature.

[1] Staley, *Trans. Amer. Ceram. Soc.*, **17**, 702 (1915).

(4) Capillary structure of the piece.
(5) Rate of drying.
(6) Amount of water to be removed.

Solubility.—The more soluble the compound the more freely it is taken into solution and the greater the amount of efflorescence. Thus the formation of barium sulfate in the ware is not a source of trouble because one part requires approximately 435,000 parts of water to dissolve it. On the other hand, magnesium sulfate is extremely troublesome because one part dissolves in 3.75 parts of water.

Size of the Particle.—Gypsum, *i. e.*, the mineral calcium sulfate, if present, which is a frequent occurrence, will be found in lumps, grains, films and as minute crystals. The carbonate of lime may be present in lumps and grains of widely varying sizes. The carbonate of iron will be found in a great variety of sizes. The sulfates of iron, aluminum and magnesium are present probably as small crystals, films or stains. It is scarcely necessary to state that the size of the particle has a direct bearing upon the rate at which it will go into solution. Choosing a homely example of this, we know that granulated sugar dissolves more rapidly in a cup of tea than a lump of the same.

Temperature.—In general, chemical compounds dissolve more rapidly in hot water than in cold. Therefore as the clay wares are warmed in the course of the drying, a greater amount of the soluble compounds goes into solution.

Capillary Structure of the Ware.—All unburned clay wares and much of the burned are permeated with an extensive system of connected pores or tubes of extremely small diameters which we call capillaries. Through these capillaries the water in the ware makes its way to the surface during the drying process. The movement of the water in the capillaries is greatly retarded by irregularities in the walls and the tortuous path which they follow. Also, the rate of flow in the capillaries diminishes rapidly as the diameters of the capillaries decrease in size. Therefore, we find that the finest grain clays have the most extensive system but the smallest capillaries and accordingly dry the slowest. The slow rate of drying is most favorable for the solution of the salts. In so far as we can open up the structure of the wares, that is, create a system of large capillaries in place of the finer ones, to that extent we hasten the progress of the drying, reduce the time that the water can exert its solvent action and lessen the amount of efflorescence. An excellent example of this phase is the fact that dry press brick do not often show efflorescence. This is due in part to the fact that a minimum amount of water is used in the process of manufacture and also to the more porous structure of the ware during the drying and early stages of the firing.

Rate of Drying.—As previously stated the longer the water in the

clay ware stands in contact with the soluble salts, the greater the amount that will go into solution, especially as the temperature increases. It naturally follows that the drying operation should be carried through as rapidly as is consistent with safety. If the drying operations are so imperfect as to subject the ware to an atmosphere so charged with humidity that moisture condenses on the colder brick, which sometimes happens, the moisture thus condensed may readily penetrate the surface of the ware and take into solution large quantities of the salts.

Use of Organic Coatings.—It has been proposed to coat the clay wares with glue, flour, starch or rubber before drying. This may act in a favorable manner in at least two ways. (1) The drying proceeds through the evaporation of water from the surface. If a surface is coated in such a manner as to retard or prevent the evaporation of the water from it, then the chief movement of the water will be to and from the uncoated surfaces. That is, the course of the movement of the water current carrying the soluble salts will be to the other surfaces where they may not be objectionable. (2) The soluble salts, *i. e.*, sulfates are decomposed during the burning operation and rendered unobjectionable. (3) The soluble salts may be carried into the surface coating and there deposited. Subsequently the coating dries and falls off. This may apply to the use of flour, starch and glue but not to the use of tar as has been proposed.

A Test for the Presence of the Salts on Dried Ware.—After the ware has been dried, scrape off a portion of the surface of the same and then burn the ware under such conditions as to prevent the formation of the kiln white. If the burned ware shows salts on the unscraped portion, but not on the scraped, it is obvious where the trouble originated.

Setting of the Brick on the Drier Cars.—The manner of placing the brick upon the drier cars must have an influence upon the movement of the water in the ware and consequently the place of deposition of the salts. That is to say, the faces of the brick which are exposed to the air dry freely while those in contact dry only by the removal of the water through the capillaries leading to the outer surfaces. Therefore, the efflorescence appears on the exposed surfaces only.

Kiln White.—According to the classification previously discussed we may consider the occurrence of surface coatings upon burned ware under two heads, namely, efflorescence and scum.

Efflorescence.—That is the deposition upon the surface of soluble salts which have originated in the interior of the ware and have been brought to the surface in solution. These may have been present originally in the raw clay and may have come to the surface during the drying process in the driers or during the early state of the firing.

Scum.—This is the surface coating of salts formed by the action of kiln gases during the early period of the burn. The chief and probably

only offenders are the oxides of sulfur—sulfur dioxides and sulfur trioxide —which are evolved by the burning fuel and by the decomposition of the pyrites present in the clay. It is altogether likely that we have chlorides of sodium and other bases present in the fuel which react in some way with the clay wares, but it is doubtful that they have a harmful effect upon the ware. If present during any part of the burning period they are decomposed and react upon the clay wares without leaving any surface indications. As I will show further on, these chlorides may exert a different effect during the cooling period.

Sulfur in the Fuel.—All fuels contain variable amounts of sulfur occurring in different forms. Wood is practically free from it and the little which it contains has a negligible influence upon clay wares. Therefore, it has long been esteemed the most desirable fuel for use in burning decorated pottery, since the colors will then give the most desired effects. However, wood is no longer available in sufficient quantity and sufficiently cheap to be considered as an available fuel for most clay wares.

Peat, which is an abundant fuel in some parts of this and other countries, is also a desirable fuel for the same reason.

However, the fuels which are available in quantity and at a suitable price contain more rather than less sulfur and the problem is to use them intelligently in order to minimize the inherent bad qualities.

Sulfur is present in coal, oil and gas in a variety of forms. The most readily distinguished and most abundant in coal is the sulfide of iron. Sulfide of iron is one of the important raw materials used in the manufacture of sulfuric acid. The other essential raw materials are free oxygen and water. When fuel containing pyrites is burned in a furnace of any type we have the same materials and the same conditions as are obtained in the manufacture of sulfuric acid. If the temperature of the kiln is sufficiently high, this acid will pass through the kiln with little or no effect upon the ware. But during the early stages of the burn the story is quite different.

Brick set in a kiln are never entirely dry. Usually the drying process falls far short of being complete and a considerable amount of water is retained. Even when dried at 212° F the clay clings tenaciously to a small percentage of water. But assuming that the drying operations have been ideal, as soon as the dry ware cools below its drying temperature it promptly appropriates moisture from the atmosphere which may amount to 10% of its weight. This happens during the period of its transfer from drier to the kiln and during that period in the kiln when it is at a temperature of 212° F and lower.

Part of the moisture which the clay grabs is supplied by the air passing through the kiln and part by the water which is always one of the products of combustion.

The conditions which we have to consider during the early stage of the burn are therefore—a mass of moist cold brick, and a plentiful supply of the oxides of sulfur. The result is a condensation on the moist brick of dilute sulfuric acid which clings tenaciously to the clay and attacks vigorously the mineral material. The carbonates of soda, potash, lime, magnesia and iron speedily succumb and their sulfates are formed. Other minerals offer more resistance but the oxides of iron and evidently certain silicates of alumina and other bases yield in greater or less degree. An excellent example of the course of this action is observed with limey clays. These normally burn to a cream color. Under certain conditions we obtain ware flashed red. The red color is due to the action of the sulfur gases upon the lime, changing it to the sulfate and permitting the iron oxide present to exert its normal influence upon the development of a red color.

Water-Smoking.—The proper method of treatment of a kiln during the water-smoking period of the burn is to remove the moisture from the ware and to warm up the ware as speedily as it is safe to do so. This may be accomplished by stimulating the flow of a large volume of heated air through the kiln, which may be difficult to accomplish owing to the sluggish draft of cold flues and stack. If so, a fan may be used advantageously or the kiln may be connected with a stack which is serving a kiln already under high fire, or a small fire may be built at the base of the stack.

Further it is of advantage to water-smoke with fuel having a low sulfur content such as wood, anthracite coal or coke. All of these fuels are used in various parts of the country during the water-smoking period with good effect.

Setting of the Ware.—The manner in which ware is set has much influence upon the progress and amount of scumming and efflorescence. Ware set too closely in a kiln retards the draft and thereby facilitates scumming. A friend recently showed me an example of brown scumming which developed on brick set in an open kiln. It has been suggested as an explanation for this case that the courses were set too closely, especially at the top and therefore the acid gases attacked available iron and alumina compounds forming soluble salts which left a yellowish brown discoloration. A similar occurrence is reported to have been observed on buff brick burning in the ordinary kilns with crowns.

As already explained, the portions of bricks which are in contact with each other do not show the salts, but only the exterior surfaces exposed to the kiln gases.

Oxidation and Reduction.—The oxidation of the pyrites to form sulfuric acid takes place only in the presence of an ample supply of free oxygen. The sulfates of lime, magnesia and the alkalies form therefore

only under oxidizing conditions. It naturally follows that reducing condition, *i. e.*, burning with an insufficient supply of oxygen is unfavorable for the formation of sulfates. Consequently, we have the use of reducing condition as a method of preventing the development of sulfates. Also by reduction it is possible to convert the sulfates already formed into sulfites which decompose readily under the influence of heat.

Influence of Hard Burning.—The amount of soluble salts formed on burned ware does not seem to be closely related to the amount of soluble salts in the clay. However, the amount of soluble salts in ware decreases as we burn the ware at higher temperatures, for example:

A soft burned brick contained 0.4 to 0.5 per cent soluble salts. The same brick burned harder contained only 0.001–0.003 per cent soluble salts.

Ries[1] cites an example of a limey Wisconsin clay which contained a few tenths of a per cent soluble material. When burned at different temperatures it gave the following results:

A—softest burn.....	4.50% sol. salts
B	2.20% sol. salts
C	1.42
D	1.23
E—hardest burn.....	1.03% sol. salts

However, as shown in the above table only part of the soluble salts becomes fixed. Another investigator[2] found that only a little more than a third of the total soluble salts were fixed by burning of a fire brick.

Experiments of A. E. Williams[3]—Laboratory experiments on the effect of volatilizing ferric chloride in the kiln during the burning gave good red colors free from scumming. Factory experiments on the application of a solution of two pounds per gallon per three thousand bricks was promising of good results although not quite satisfactory. Similar experiments using a solution of the sulfate of iron and applying it to the damp brick prevented scumming, but was not as effective as the ferric chloride.

Alkaline Scum.—According to Searle's *Clayworkers' Handbook*[4] this may be due to the use of oil containing soap. It appears as patches of glazed surface on the ware.

Temporary Scum.—A form of soluble salts which apparently has not been discussed in literature, although seemingly frequently observed, is the appearance of a whitish coating upon brick in the kiln after opening the same, especially upon those near the door; or appearing upon the

[1] Ries, *Rept. Wis. Geol. Surv.*, p. 21.
[2] *Trans. Amer. Ceram. Soc.*, **18**, 611 (1916).
[3] *Ibid.*, **17**, 764 (1915).
[4] P. 335.

brick soon after removal from the kiln. Its appearance seems to be influenced by general atmospheric conditions. Further, this white coating is readily removed by washing the brick and once removed is permanently gone.

The recent microchemical examination in our laboratory of some bricks with such a coating showed that the deposit was chiefly sodium sulfate with sodium chloride (common salt), a little calcium sulfate and no magnesium sulfate. This result is surprising and very interesting.

My inference from this analysis is that these salts were deposited during the cooling of the kiln and that they do not originate in the ware.

My reasons are as follows:

If they had been present in the ware, the sodium chloride particularly would have been volatilized and dissipated in the kiln gases or decomposed and the sodium would have attacked the clay and become permanently fixed. Just as for example in salt glazing, the salt thrown into the kiln is converted into a gas and is decomposed by the hot ware forming a glaze. The sodium sulfate either was volatilized and deposited on the ware, or more probably salt vapor was present and was attacked and changed to sodium sulfate. The ware does not show a glaze because the amount of these salts is small and because they are deposited at a *temperature too low to form* a glaze.

The source of the sodium which has formed the chloride and the sulfate is probably the fuel left on the grates during the cooling, or the ashes and clinker. For example, we know that certain coals contain notable quantities of sodium chloride, so much so that the effect of it upon refractories in coking furnaces is being carefully studied in England.

The sulfur oxides which have combined with the sodium to form the sulfate have come from the burning fuel left on the grates and from the clinker.

These salts are both readily soluble in water and may be easily and permanently removed by washing the brick.

To prevent their occurrence, if I am correct in my theory of their formation, the fire boxes and ash pits should be cleaned of their contents when the firing is completed, and before cooling.

I offer the above opinion as tentative and subject to modification, realizing that we still have much to learn about this peculiar occurrence.

Wall White.—The occurrence of a coating of white soluble salts upon brick set in the wall is known as "wall white," "wall saltpetre" or "wall nitre." Other discolorations, yellow, green, brown, etc., sometimes are observed. These may be due to the presence of vanadium salts,[1] vegetable growths, etc., which we will not discuss. The causes which bring about the formation of the soluble salts in the crude clay in the drying

[1] Seger's "Collected Writings," p. 381 (Trans. by Amer. Ceram. Soc.).

and the burning operations have already been mentioned. Bricks which normally are free from soluble salts, sometimes show them after standing in stock piles, or when built into the wall. The salts will be observed if the stock piles are built upon ground covered with cinders, ashes or slag.

The appearance of soluble salts upon brick built into the wall may be expected if soluble salts are present in the mortar or if lime is used too freely in the mortar batch. Professor Kloes in his interesting book, "A Manual for Masons"[1] says that the "addition of lime to Portland cement is about the worst thing that can be done," and he cites numerous instances of the bad results following such a practice. He advocates the addition of some hydraulic agent such as kieselguhr (*i. e.*, infusorial earth), powdered brick, slag, etc., to the lime-cement mortar to prevent the leaching out of the soluble salts.

Notwithstanding Professor Kloes' opinion, the addition of lime to Portland cement mortar is a very common practice because it renders the mortar more easily workable under the trowel, is supposed to act as a waterproofing agent in the mortar and to some degree lessens the cost of the mortar. Numerous instances of the pernicious effects of its excessive or improper use with brick, glazed brick and architectural terra cotta may be cited, however, in substantiation of his views.

The addition of gypsum or plaster of paris to Portland cement mortar makes it more plastic and easier to set, but it is altogether probable that it will find its way eventually to the surface of the brick and appear as wall white. Therefore, its presence in or addition to mortar is highly objectionable.

Of course, soft burned porous brick are much more likely to develop "wall white" than the hard burned brick of low porosity. The porous brick are easily wetted by rains and the water thus absorbed gradually dissolves and brings to the surface fresh additions of salts.

Care in waterproofing certain parts of the masonry such as foundations, parapet walls and cornices should be observed. Manufacturers of architectural terra cotta have learned from experience the great importance of care in preventing the access of water to the body of their wares when built into structures.

Soluble salts on masonry may arise, also, from the "kind" of sand used in the mortar, from their presence in the mortar, colors which are used, from the addition of salt to water used in mixing mortar in very cold weather.

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[1] Translation by A. B. Searle, p. 148.

NEED FOR MORE REFRACTORY HEAT INSULATORS

Proposed Conductometers for Measuring Thermal Conductivity[1]

By Robt. D. Pike

ABSTRACT

The commercial value of high temperature thermal insulators is discussed, and a numerical example of a problem in designing a flue for conducting hot gases is given. A suggestion is offered for carrying out research in the manufacture of more highly refractory thermal insulators than are at present available, and tentative specifications for refractory and insulating properties are given. It is further suggested that refractory manufacturers should interest themselves in such research. The need of a simple apparatus, called for convenience a conductometer, for carrying out routine investigations of thermal conductivity, is pointed out, and, after describing some of the more important apparatus formerly used, a design of an improved new type is suggested and the method of working up the results is described.

Introduction

One of the pressing needs of the combustion engineer is an enforceable specification covering both the refractory and heat insulating properties of refractory and insulating materials. This will call for a greater combination of refractoriness and insulation than is at present attainable. So far as known to the writer, the optimum combination of these two properties is now found in a brick made from calcined diatomaceous earth. The makers claim that this brick may be safely used up to 2300°F and that the conductivity in English units (K) varies from 1 to 3. Several insulating bricks are obtainable which can be safely used up to 1600–1700°F and which have a conductivity (K) of 1 to 1.5.

There appears to have been no consistent attempt to place on the market insulating bricks which could safely be used at temperatures in excess of 2300°F and which would possess considerable value as heat insulators. There is no theoretical reason why such bricks could not be manufactured, and furthermore there is no doubt of their great prospective value in many cases.

To illustrate one aspect of this value the writer has worked out a numerical example of insulating a flue, in which a hypothetical high temperature insulator is employed. This example is an extreme case, and has been so chosen to clearly bring out the point.

Example Showing Need of Refractory Insulation

The structure considered is a vertical flue of inside dimensions 18″ x 18″. This flue carries clean gases of combustion at a temperature of 2800°F at a velocity of 16 feet per second. It is proposed to construct this flue out of refractory and insulating materials. Suppose the designer had at his disposal only the following:

[1] Refractories Division, St. Louis Meeting, Feb., 1922.

Fire brick with conductivity (K) = 9.
Non-refractory insulating brick good to 1600°F with $K = 1$
Common brick.

The flue would then be constructed somewhat as in Fig. 1. The heat loss due to radiation and convection to the outside atmosphere for every foot of the flue is about 4750 B. t. u. per hour; the temperature of the inside face of the insulating brick is 1650°F and the weight per linear foot is about 2440 pounds.

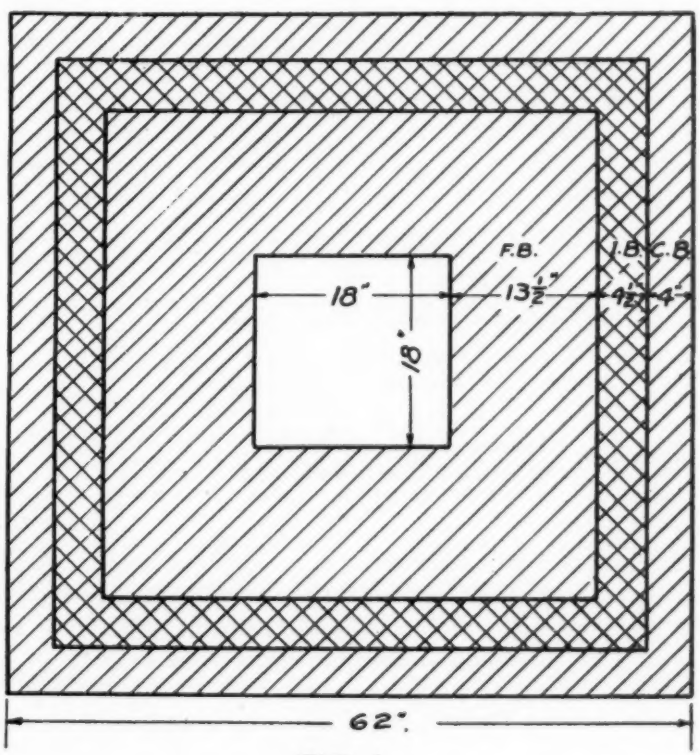


FIG. 1.

LINING 13½" F.B.
4½" I.B. (NON-REFRACTORY)
4" C.B.

But suppose in addition to the materials listed above the designer had at his disposal the following refractory insulating bricks (high temperature insulator). Refractory insulating brick good for exposure to clean gas at 2800°F and having $K = 2$ and possessing the necessary structural strength for the intended service.

Under these circumstances the flue could be built as shown in Fig. 2. The loss per linear foot would be 2900 B. t. u. per hour; the temperature of the inside face of the non-refractory insulating brick would be about 1640°F and the weight per linear foot would be about 866 pounds.

The flue shown in Fig. 2 would weigh only 35.5% of that shown in Fig. 1, and the heat loss would only be 61.0% as great.

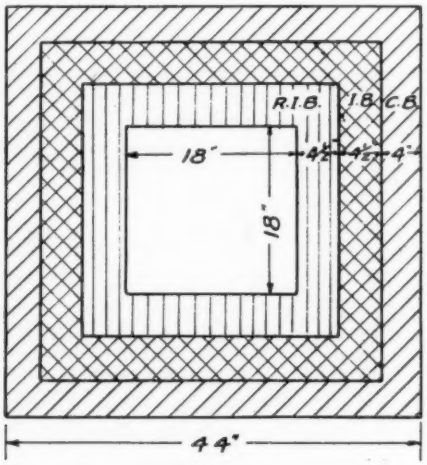


FIG. 2.
LINING 4½" REFRACTORY INSULATING MATERIAL R.I.B.
4½" INSULATING BRICK (I.B.) (NON-REFRACTORY)
4" C.B.

In the foregoing example Langmuir's[1] data has been used for estimating the thermal resistance of the surface film of gas inside the flue and the loss of heat by radiation and convection from the outside surface; and Langmuir's[2] formula has been used for calculating the shape factor.

Relation between Flare of Walls and Insulating Requirements

As already pointed out, this example represents an extreme case, and this is principally so because of the sharp flare of the walls of the flue, and to the highly favorable nature of the hypothetical high temperature insulator. But all furnace walls have more or less flare, and on this account alone the closer the heat insulator can be placed to the inside surface, the lighter in weight will be the structure and the better the insulation; and furthermore even when the flow of heat through a wall may be con-

[1] "The Convection and Radiation of Heat," by Irving Langmuir, *Trans. Am. Elec. Chem. Soc.*, **1913.**

[2] "Flow of Heat through Furnace Walls;" "The Shape Factor," by Irving Langmuir, E. Q. Adams and C. S. Meikle, *Trans. Am. Elec. Chem. Soc.*, **1913.**

sidered to take place in parallel flow lines without serious error, *i. e.*, when there is little or no flare, it is obvious that the more refractory the heat insulator, the closer it can be placed to the inside surface of the furnace, and the thinner can be the refractory lining, and the lighter the weight of the entire structure.

Where Insulation Is Sacrificed for Want of Refractoriness

An important conclusion arising from consideration of the flare of furnace walls is that insulating property can be sacrificed to some extent if there is a corresponding gain in refractory property while maintaining equal insulation effect, and this fact opens up the possibility of a new type of brick which would find application in a large number of structures, *i. e.*, in all furnaces, flues, etc., where the flare of the walls is a factor.

Research and experience alone will finally show just what combinations of refractory and insulating properties may be attained in practice, but the following table may be considered as a tentative suggestion, covering the entire range from non-refractory insulating to refractory non-insulating materials.

TABLE I

TENTATIVE RANGE OF REFRACTORY AND INSULATING PROPERTIES OF MATERIALS FOR FURNACE CONSTRUCTION

Type	Approximate upper limit of working temperature when exposed to clean non-corrosive gases	Conductivity *K* Eng. units at average working temperature	Present state of art
1. Refractory, non-insulating	2700 °F–3000 °F	8–10	Represented by commercial refractory bricks.
2. Semi-insulating refractory	2600 °F–2800 °F	3.0–5.0	Hypothetical material.
3. Refractory insulator. High temperature insulator	2500 °F–2800 °F	1.5–3.0	Hypothetical material.
4. Insulating, semi-refractory	2300 °F	1–3	Bricks made from calcined diatomaceous earth.
5. Insulating non-refractory	1600 °F	1–1.5	Bricks made from diatomaceous earth and like substances.

Consideration of placing insulation back of refractories, involves the ability of the refractory to withstand the more severe heat conditions. Thus far the refractory manufacturer, and the maker of insulating materials

have followed more or less independent paths; without evincing that reciprocal interest in each other, which is needed to place at the disposal of the furnace designer, the materials for most efficient design, all factors being considered.

Need of Refractories Having Insulating Properties

The writer ventures to urge that refractory manufacturers begin to give attention to the heat insulating aspect of refractory bricks in addition to the other properties now embodied in standard specifications. In short, a question of this sort should be answerable; given certain conditions of temperature, gas velocity, dust conditions, etc., on the inside of a wall, how much insulation may be safely applied on the outside? Or, putting the matter in another way, What is the smallest temperature gradient through the refractory compatible with safety and long life? And beyond this, the further suggestion is urged that refractory manufacturers undertake research in the manufacture of high temperature refractories occupying the upper region of the foregoing tentative table. Such research can be followed along the lines of experimenting with various sizes and numbers of pore spaces in a given volume, combined with various refractory bodies.

The successful manufacturing of insulating materials demands an apparatus capable of commercial application for determining with a fair degree of accuracy the conductivity at different temperatures. The writer would not go so far as to say that such an apparatus is not available, but certainly it would seem that none such has been adopted. Possibly this is because of the complexity of the various types of apparatus described in the literature, and the very evident lack of any uniformity in method among experimenters. Thus far the measurement of thermal conductivity appears to have been most largely laboratory research rather than routine commercial testing or control of a commercial process.

Methods of Measuring Heat Conductivity

Clement and Egy[1] measure the current input into an electrical resistance placed along the axis of a special hollow cylindrical test piece; and determine the temperature at two points in the wall. The necessity for using a special test piece rules out such a method for practical routine work.

Griffiths[2] reviews the work of other investigators and points out the requirements for the accurate use of the flow calorimeter. Readings were made at several temperatures and several days were required to

[1] "The Thermal Conductivity of Fire Clay at High Temperatures," by J. K. Clement and W. L. Egy, *Univ. of Ill. Bull.*, **6**, No. 42, Aug. 2, 1909.

[2] "The Thermal Conductivity of Materials Employed in Furnace Construction," by Ezer Griffiths, *Trans. Faraday Soc.*, **12**, 193–206 (1919).

complete a test on one specimen, because a new steady state had to be reached for each temperature.

Dougill, Hedsman and Cobb[1] used a flow calorimeter.

The temperature of the hot face of the test brick was maintained by a gas burner and thermocouples were placed in the hot and cold face of the test piece. This method suffers from the same disadvantage as the preceding one of Griffiths, in that a separate steady state of temperature must be attained in the test piece for the determination of conductivity corresponding to each different mean temperature between the faces.

Dudley[2] constructed a coke-fired furnace, one wall of which held the test brick. A flow calorimeter with guard ring was used and temperature readings were made every quarter inch from the hot to the cold face. By this means Dudley was able to calculate the temperature coefficient of conductivity from a single set of readings which enabled him to complete one test a day. The thermocouples were inserted into the brick perpendicular to the isothermal planes, whereas for accurate work the couple wires should parallel the isothermal planes. In addition to this criticism the apparatus is rather cumbersome.

Randolph[3] used a flow calorimeter with guard ring, and an electrically heated hot plate. There are no new features as compared with Griffiths.

Heyn, Bauer and Wetzel,[4] used an entirely different method, inasmuch as a steady state was not reached and time was considered as one of the variables. The test piece was heated quickly from a hot face and the cold end acted in effect as a calorimeter. The conductivity was calculated from the time temperature curve of two couples, one at the hot face and the other 1 to 2 cm. distant, combined with a determination of the specific heat of the specimen. No calorimeter was required nor was it necessary to reach a steady state, but in spite of this simplification it is doubtful if the method is of value owing to the involved method of calculation, particularly in view of the fact that the results obtained are not closely comparable to those obtained from the flow calorimeter method.

Goerens and Gilles[5] placed the test brick over an electric hot plate. Several thermocouples were inserted in holes drilled to the center of the test piece and parallel to the isothermal planes. The test piece was sur-

[1] "The Thermal Conductivity of Refractory Materials," by G. Dougill, H. J. Hedsman and J. W. Cobb, *J. Soc. Chem. Ind.*, **34,** 465–71 (1915).

[2] "The Thermal Conductivity of Refractories," by Boyd Dudley, Jr., *Trans. Am. Elec. Chem. Soc.*, **1915**.

[3] "The Thermal Resistivity of Insulating Materials," by C. P. Randolph, *Trans. Am. Elec. Chem. Soc.*, **1912**.

[4] "Untersuchungen über die Wärmeleitfähigkeit feuerfester Baustoffe," Mitteilungen ausdem Königlichen Materialprüfungsamt, **32,** 89 (1914).

[5] "Über die Wärmeleitfähigkeit feuerfester Steine," by Von P. Goerens and J. W. Gilles, *Ferrum*; October, **1914.**

rounded by heavy insulation to insure parallel flow of heat from the hot face to the flow calorimeter, the central part of which occupied about one-third the area of the cold face, the balance of the cold face being covered by the guard ring of the calorimeter. This apparatus appears to be theoretically correct and practical in construction and is the closest approach to a practical apparatus for commercial work that is described in the literature. In fact, it is quite possible that an apparatus of this type could be adapted to routine work.

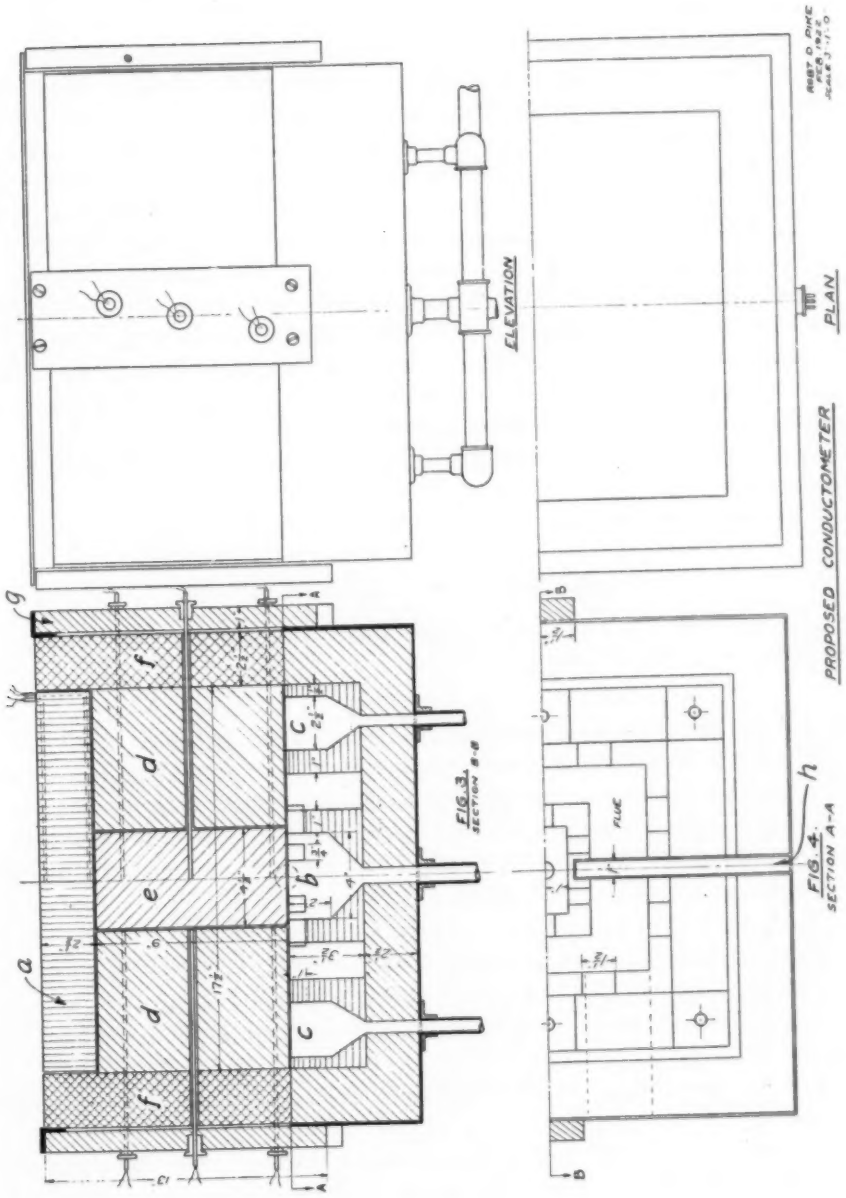
The proposed new instrument for measuring the thermal conductivity of standard nine-inch bricks of refractory and insulating materials is shown in Figs. 3 and 4. The principle of operation is to measure the temperature drop at one instant at several points along a bundle of heat flow lines of extremely small cross sectional area. This method is distinct from that used in a similar type of apparatus when a flow calorimeter is used to measure the heat flow. In this latter case the actual flow of heat passing a relatively large cross-sectional area of the test piece is measured during an appreciable time interval.

Proposed Commercial Control Apparatus

The proposed apparatus is in many respects similar to that of Goerens and Gilles,[1] but the flow calorimeter is supplanted by a disc-like member (*A*, in the Figures), having thermocouples embedded in its upper and lower faces and possessing a known thermal resistance. (It is presumed that this known thermal resistance will have been established once for all by the flow calorimeter method.) In short, any given difference in temperature of the two couples embedded in the disc shows immediately the rate of heat flow per unit area at the center of the disc, when such flow is perpendicular to the respective faces.

Referring further to Figs. 3 and 4, *b* is a centrally located surface combustion burner in a carborundum pot designed to hold the test brick on its end or on its side (the latter disposition would be used when the test piece was composed of highly insulating material). *c*, is a "guard ring" burner, which sets up a heat flux in the material, *d*, which has substantially the same conductivity as the test piece, *e*. *f* is an insulating covering. *g* is a transite board standard, drilled to hold the thermocouples in accurate alignment. The test piece is drilled with 3 (or 6) holes to center, through a template corresponding to the holes in the transite standard. It is then inserted in the central hole over the burner, *b*, and the thermocouples pressed home and secured. A smooth upper surface is then secured with a suitable cement and the standard resistance, *a*, is pressed into place. The resistance of this latter is so chosen that for the given test piece, when

[1] *Vide supra.*


ELEVATION
PLAN
PROPOSED CONDUCTOMETER
FIG. 3.
SECTION B-B
FIG. 4.
SECTION A-A
FLUE
a
b
c
d
e
f
g
h

the hot face is at its maximum steady temperature, about two-thirds of the total temperature drop will be across the test piece and one-third across the standard disc.

The burners are turned on and when a steady state has been reached, as indicated by observations with an optical pyrometer, through the carborundum tube, *h*, and by the attainment of a flat time temperature curve with the thermocouple nearest to the cold end of the test brick, a simultaneous set of readings is then taken on all the thermocouples, *i. e.*, on the 3 (or 6) embedded in the test piece, and the two embedded in the standard disc. This gives the data necessary for calculating the conductivity of the test piece expressed as a straight line function of the temperature.

The thermocouples which are embedded in the guard ring refractory are to insure that the temperature gradient through this near the test piece is substantially the same as the temperature gradient through the test piece, which condition insures parallel flow of heat along the central axis of the latter and along the central axis of the standard disc.

It should be possible to examine at least two specimens daily with such apparatus.

The mathematical basis of the calculation is given in the following:

Mathematical Considerations

Conductivity (K) is a straight line function of temperature, T, in accordance with the following equation:

$$K = a + bT \qquad (1)$$

in which a and b are constants characteristic of the substance.

If one will write the differential equation for the parallel flow of heat between two infinitely close isothermal planes, substituting therein the value of K from Equation 1 and then obtaining the definite integral, the following equation results, which defines the temperature gradient

$$a(T - T_1) + \tfrac{b}{2}(T^2 - T_1^2) + Wx = o \qquad (2)$$

In which

a and b are the constants of Equation 1

T_1 is the temperature in °F on any hotter isothermal plane.

T is the temperature in °F on any cooler isothermal plane distant X inches from the hotter plane.

W is the flow of heat from the hotter to the cooler plane in B. t. u. per square feet per hour.

Returning now to the set of instantaneous readings from the proposed conductometer the temperature of the inner and outer faces of the standard disc immediately show the rate of heat flow per square foot per hour at the center of the disc and test piece from the known calibration of the former. This gives W of Equation 2.

Next, there are at least three temperature readings at measured points along the axis of the test piece. Call these points 1, 2, 3, reading from the hotter to the colder end. Equation 2 is now written substituting therein the value of T_1 for point 1 and T for point 2; and is again written this time calling the temperature at point 2, T_1 and at point 3, T; X is of course known in each case, because it is merely the distance between the thermocouples. This gives two equations from which the values of a and b can be solved, and substituting these values in Equation 1 gives the desired result.

If six readings are made in the test piece, these are divided into 2 sets of 3 each, and the same procedure is followed giving two independent sets of values for a and b. Theoretically these two sets of values should be identical, but actually there would always be some difference between them because of experimental error and the averages of the two sets should be used as the final result.

Dudley[1] in calculating his results uses a method which is essentially the same as the one described except that he first determined the shape of the temperature gradient curve and having found this calculated that the conductivity-temperature curve is a straight line. The writer uses this latter fact as the basis for his calculation.

It will be desirable in the interest of accurate determination of a and b to have the temperature of the hot face of the test piece at as high a point as permissible, considering the nature of the material, and it would seem that the use of the surface combustion principle would render this possible in all cases.

The hot face temperature can be attained if desired by any sort of an electric resistance.

It will be noted that the apparatus divides at the top of the carborundum pots, and the test piece and guard ring and insulation can be removed as a whole.

The writer has hesitated somewhat in presenting this paper because of the purely tentative and suggestive nature of the subject matter; but consideration of the urgent needs for development along the line of insulating all sorts of metallurgical furnaces finally brought the decision that its presentation would prove worth while if it only should result in some fresh discussion of the subject; or should give other workers in the same field some small suggestion for future improvement.

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SAN FRANCISCO, CAL.

[1] *Vide supra.*

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M. F. Beecher
A. F. Greaves-Walker
(b) **Raw Materials:**
D. W. Ross
M. C. Booze
E. C. Hill
(c) **Standardization of Tests:**
All selected by Divisions
(d) **Standardization of Products:**
All selected by Divisions

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CERAMIC ABSTRACTS

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Vol. 1 August, 1922 No. 8

Authors Index[1] to Abstracts for August

Author	Number of abstract
Andrieux, L.	71
Anon.	2, 13, 45, 51, 68, 92, 93, 94, 95, 96, 98, 100, 103, 104, 107, 131, 132, 135
Arrhenius, O.	49
Balz, George A.	79
Bansen, Hugo	72
Barba, W. P. and Howe, H. M.	69
Binder, F. O. H.	7, 32
Bingham, E. C.	16
Blanc, E. C.	3
Blücher, H.	8
Blyth, Herbert	17
Bräuer, Adolf	29
Broeksmit, T. C. N.	43
Brophy, G. R.	12
Buch, A. E.	110
Burton, E. F. and Bishop, Miss E.	56
Busby, H. S.	91
Chevenard, P.	11
Clapp, Albert L.	123
Clawson, Monroe S.	39
Clouser, Harry E. and Thornton, Edgar R.	111
Collins, Daniel Elijah	82
Comber, N. M.	14
Cornille, Alex.	83
Couch, James F.	5
Cutler, F. G.	70
Daeves, Karl	30
Dahle, Anti	1
Dautrebande, Jules	128
Davey, Wheeler P.	27
Dufva, K. O.	138
Endell, K.	64, 75
Etchells, Harry	73
Eucken, A.	58
Fischler, M.	31
Formby, George M.	140
Forsythe, W. E.	33
Frydlender, J. H.	9
Funk, W.	84
Greaves-Walker, A. F.	65
Greisen, E. C.	18
Glasstone, S.	41
Grün, Richard	134
Haigh,	99
Hall, E. E.	127
Hartman, Noble	118
Heike, W.	42
Hoffman, Otto	10
Howe, J. A.	44
Imhoff, W. G.	38
Ives, H. E.	90
Jeffery, Joseph A.	89
Jones, J. B.	139
Jones, M. C. K.	34
Kahr, August	113
Kallauner, O. and Fiser, J.	97
Knipp, C. T.	28
Kolthoff, I. M.	48
Kowalke, O. L.	35
Kröger, M.	46, 47
Lang, R.	59
Lee, J. W. and Hebden, G. A.	77
Le Guen	130
Lidstone, F. M.	20
Lotka, A. J.	57
Mackowsky, H.	101
Manchot, W. and Funk, H.	61
Marino, O.	125
Mauge, Lucien	37
McAdams, W. H. and Frost, T. H.	52
Meade, Alwyne	4
Minovici, S. and Ionescu, A.	50
Morrison, M. L.	78
Narbutt, J.	54
Office, L. R.	76
Peirce, Thomas W.	114
Petts, Elias	105
Pollacsek, E.	112
Poulson, A. and Rourke, C. J.	24
Prausnitz, P. H.	15
Rebuffat, O.	63
Reid, A. E.	81
Reutlinger, E.	106
Richards, W. E. W.	141
Rieke, R.	108
Rieke, R. and Gary, M.	88
Riffle, Jerome B. and Hartman, Louis H.	23
Robson, H. C.	36
Sampelayo, P. H.	74
Sauer, U.	85
Schiff, S.	142
Schmidt, Harry	109

[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

Author Index to Abstracts for August (*Continued*)

Author	Number of abstract
Schoeller, W. R.	19
Schott, Dr.	136
Scohy, John R.	124
Sebring, Charles L.	21
Selch, E. and Garstenauer, R.	40
Shertzer, T. B.	137
Sortwell, H. H.	86
Steger, Dr. W.	62
Stettbacher, A.	133
Straight, Halver R.	22
Sugden, S.	55
Sullivan, E. C. and Taylor, W. C.	115, 119
Tadakoro, Y.	67
Taffin	117
Taylor, William Chittenden	121, 122
Tostman, C.	87
Tsountas, C.	129
Urbasch, S.	60
Varian, J. P.	66
Vennootschap, Naamlooze	126
Weisenberger, Jacob	120
Wheeler, R. V.	26
Whipple, R. S.	25
Whitman, W. G. and Keats, J. L.	53
Wietzel, Rudolf	116
Williams, J. P.	102
Witte, G. A.	6
Wright, J. A.	80

General and Miscellaneous

1. Dry purification of kaolins. ANTI DAHLE. *Sprechsaal*, **54,** 393–396(1922).—The sepn. of graphite by air currents has been highly perfected. This sepn. is possible because of the sp. gr. of the different ingredients. Thus graphite has a sp. gr. of 1.9–2.3, quartz 2.5–2.8, granite 2.3–3.00, mica 2.6–3.2 and clay 1.8–2.6. Similarly the sp. gr. of kaolin is 2.2–2.6, quartz 2.5–2.8, feldspar 2.5–2.6 and mica 2.6–3.2. Two methods are used and are known as (1) air or wind separators and (2) centrifugal separators. In the first type powdered kaolin is drawn thru a chamber by means of an air current and the heavy and coarser material is deposited. By this method the crude kaolin may be separated into the following portions (1) kaolin powder, (2) coarse kaolin, (3) quartz particles, (4) feldspar particles, (5) mica particles, (6) some quartz particles, (7) some feldspar particles, and (8) crude kaolin. By means of the centrifugal process the kaolin may be separated into the following portions and in combination with the air sepn. may be still further refined. Product (1) after screening from mica and org. matter a pure kaolin is obtained. Product (3) consists of feldpar and quartz and is discarded. Product (4) is crushed a second time in rolls and again run through the separator. Product (2) is passed through the rolls and then is passed to the wind separator which separates this portion into four portions, one of which is pure kaolin. The opern. has to be adjusted for each clay. H. G. SCHURECHT

2. Monorail conveyors on clay plants. ANON. *Brick and Clay Record*, **60,** 613–615 (1922).—Overhead monorail conveyors system is described for handling both the raw material and ware in the various stages of its manuf. H. G. SCHURECHT

3. Modern installation for crushing and screening basalt. E. C. BLANC. *Rev. Mat. Constr. Trav. Pub.*, **149,** 31–34(1922).—Basalt from a certain quarry in the middle of France is crushed and screened and used for railroad and road making. A plan and photographs of the plant are given with descriptions of mech. crushers and sorters. LOUIS NAVIAS

4. Some practical considerations with handling plant. ALWYNE MEADE. *Chem. Age* (London), **6,** 228–9(1922).—Need for considering depreciations in selection of mech. handling devices for chem. plants is pointed out. Construction of storage hoppers for hard and abrasive materials is discussed. A. E. MARSHALL (*C. A.*)

5. The evolution of chemical terminology. I. Coagulation. JAMES F. COUCH. *Am. J. Pharm.*, **94,** 92–7(1922).—A review and discussion. W. G. GAESSLER (*C. A.*)

6. Electrical precipitation of cement mill dust. G. A. WITTE. *Gen. Elec. Rev.*, **25,** 125–7(1922).—Several Cottrell elec. pptn. installations are briefly described, and the flexibility in construction is noted for both the plate and pipe types. Power may be

taken from the factory line when a synchronous motor is substituted for the motor-generator set. Multiple pipe type precipitators are energized from a 75,000-v. circuit and the plate type treaters from a 50,000-v. circuit. About 5% of the total raw material fed into the kiln is recovered as collected dust. Its utility depends upon its water-sol. K value and dets. its use for CaO-K_2O fertilizer, mixed fertilizers, or leaching for production of high-grade potash salts. Dust of low potash content can be returned at regular intervals to the kiln. Domestic and foreign Cottrell installations are listed.

W. H. B. (*C. A.*)

7. Constitution and heat of combustion. F. O. H. BINDER. *Chem.-Ztg.*, **45,** 1114–6(1921); cf. *C. A.*, **16,** 10.—The heat of combustion of an org. compd. in cal. per mole may be computed from the formula: $55{,}560\,x + 23{,}570\,y + 34{,}170\,z$, where x = the no. of C-to-H bonds, y = twice the no. of single C-to-C unions, and z = twice the no. of extra C-to-C bonds. A C-to-N bond equals 35,016 cal. The article gives the results of calcns., compared to observations, for a no. of compds. The agreement is only moderately close. The ketone formula for *quinone* is less likely than the peroxide formula.

ERNEST W. THIELE (*C. A.*)

8. From laboratory experiment to factory apparatus. H. BLÜCHER. *Chem.-Ztg.*, **45,** 1133–5, 1163–5, 1182–6(1921).—This detailed discussion, contg. nothing essentially new, is written primarily for the inexperienced industrial chemist, and deals with the application of research methods to factory scale. The subjects discussed are: (*a*) quantity and nature of raw materials; (*b*) the time factor; (*c*) heating; (*d*) cooling; (*e*) high pressure technic; (*f*) vacuum; (*g*) grinding; (*h*) mixing and stirring; (*i*) settling and leaching; (*j*) filtration; (*k*) centrifuging; (*l*) distn.; (*m*) drying; (*n*) miscellaneous; (*o*) results: patents, secret processes, and marketing of product.

THEO. F. BUEHRER (*C. A.*)

9. The international chemical index and the reproduction of documents. J. H. FRYDLENDER. *Rev. prod. chim.*, **25,** 73–8(1922).—A general discussion of the problem of searching the literature on a given subject and of obtaining original articles or documents which may need to be consulted.

A. P.-C. (*C. A.*)

10. Simplified stack calculations. OTTO HOFFMANN. *Feuerungstechnik*, **10,** 53–6, 65–8, 79–82(1922).—Review of previous formulas and development of new formulas for computing stack dimensions from the conditions of the installation.

E. W. T. (*C. A.*)

11. The thermal expansion of chromium and of nickel-chromium alloys over an extended range of temperatures. P. CHEVENARD. *Compt. rend.*, **174,** 109–12(1922).—The expansion behavior of Cr over a considerable range of temp. being hitherto unrecorded, C. undertook this detn., and in addition, to study the effect of varying amts. of Cr upon the thermal expansion of Ni-Cr alloys. The expts. were performed with the differential app. previously described, in which the specimen bar is opposed by a standard bar of "Baros" (alloy of Ni-Cr contg. 10% Cr) whose rate of expansion has been directly detd. with frequent checks over the range from 0° to 1000°. Between 0° and 100° the expansion of Cr is exactly reversible, and the metal appears to be dispossessed of all thermal singularity. The true coeff., which at 0° = 6.8×10^{-6}, increases rapidly with rise in temp., the curve which traces this variation presenting a gentle concavity with increase in temp. The magnetic transformation of Ni is accompanied by rapid diminution of the true expansion coeff. and the temp. at which this change was found to occur coincides appreciably with the temp. of the Curie point detd. by thermomagnetic methods. The addition of Cr, itself having a much smaller expansion coeff. than Ni, affects little the coeff. of expansion of the latter metal at ordinary temps., but tends to increase at higher temps. This considerable disparity from the behavior of mixts. is

probably due to the presence of the compd. Ni_2Cr_3, whose existence has been established by Voss and confirmed by the author. J. T. R. ANDREWS (*C. A.*)

12. Calite—A new heat-resisting alloy. G. R. BROPHY. *Trans. Am. Soc. Steel Treating*, **2**, 384–6(1922).—Calite is an easily castable, but difficultly forgeable, alloy of Al, Ni, and Fe, which will not oxidize at temps. up to 1300°. Its m.p. is 1500°, the elec. resistivity is 112 ohms/cm.^{3}, the temp. coeff. is 0.00044, and the heat resistivity is 3.25 times that of Ni. The alloy is highly resistant to atm. corrosion, the action of acids (except HCl and H_2SO_4) molten NaCN, $BaCl_2$, S, or NaCl. It retained a perfect polish after 100 hrs. in a salt spray at 100°F. Fluxes such as cryolites, borates, and silicates attack it rapidly. The details of casting are given. W. A. MUDGE (*C. A.*)

13. First large plant using pulverized coal exclusively. ANON. *Elec. World*, **79**, 721–4(1922); illus.—A detailed account with plan of the plant shown, of 40,000 kva. central station at Milwaukee. C. G. F. (*C. A.*)

14. Characterization of clay. N. M. COMBER *J. Soc. Chem. Ind.*, **41**, 77–80T (1922).—C. concludes "The constitutional characteristic of clay which distinguishes it from other systems of siliceous mineral particles is that in clay the properties of the emulsoid and surface outweigh those of the suspensoid 'core' whereas in silt, etc., the properties of the core of the particles are not dominated by the relatively smaller amt. of emulsoid surface." WM. M. CLARK (*C. A.*)

15. Electroösmosis. P. H. PRAUSNITZ. *Z. Elektrochem.*, **28**, 27–36(1922).—A survey of expts. indicating how electroösmosis and related processes may be applied technically. The importance of further development of the electrochemistry of colloids is discussed. H. JERMAIN CREIGHTON (*C. A.*)

16. Progress in metric standardization. E. C. BINGHAM. *J. Ind. Eng. Chem.*, **14**, 332–4(1922). E. J. C. (*C. A.*)

17. The importance of low handling costs. HERBERT BLYTH. *Chem. Age* (London), **6**, 226–8(1922).—A description of the present lack of mech. handling devices in English chem. works. Pneumatic methods are given for (1) unloading from slips; (2) unloading from railroad cars; (3) conveying to storage or point of use in plant. A. E. M. (*C. A.*)

18. Preparing and distributing powdered coal. E. C. GREISEN. *Iron Age*, **109**, 326–9(1922). E. J. C. (*C. A.*)

19. Note on the production and testing of zirconia. W. R. SCHOELLER. *J. Soc. Chem. Ind.*, **40**, 127–8T(1921).—Processes for extg. zirconia from Brazilian ore by pptn. as basic sulfate (*C. A.*, **16**, 992) aim to eliminate Fe without regard to removal of Ti. Analyses of Brazilian ore by the method of Powell and Schoeller (*C. A.*, **14**, 708) show TiO_2 in quantities varying from 0.6 to 1.2%. The process based on the prepn. of crystd. $ZrOCl_2$ yields c.p. ZrO_2, but is expensive on account of the low recovery. S. modifies this process by reworking the mother liquors and wash waters obtained from the crystn. of c.p. $ZrOCl_2$ so as to obtain the remainder of the ZrO_2 in a form pure enough for industrial purposes. Analyses of samples of British zirconia show as impurities SiO_2, TiO_2, Al_2O_3, Fe_2O_3, As_2O_5, SO_3. The presence of As is highly objectionable; for its detn. 2 g. of ZrO_2 are fused with 15–20 g. Na_2CO_3 in a Pt crucible; the melt is leached with hot H_2O, the soln. filtered, acidified with HCl, and satd. with H_2S. The As_2S_3 is filtered off, evapd. with H_2SO_4 until fumes are evolved, the liquid is made alk. with $NaHCO_3$, and titrated with I soln. T. S. CARSWELL (*C. A.*)

20. The measurement of absolute viscosity. F. M. LIDSTONE. *Phil. Mag.*, **43**, 354–7(1922).—In the measurement of viscosity by the rate of flow method under varying head it is not accurate to use the mean head. If the difference between initial and final head is great the error is large. Formulas and tables are given for the accurate calcn. S. C. L. (*C. A.*)

PATENTS

21. Drying rack for pottery manufacture. CHARLES L. SEBRING. U. S. 1,410,275, March 21, 1922. In a drying rack and conveyor of the character described, a drying chamber, a compartment formed near one end of the drying chamber and provided with openings on opposite sides in the drying chamber, the adjacent end of the drying chamber being provided with an opening and a conveyor movable through a circuitous course within the drying chamber and around the compartment, the conveyor moving adjacent to all of the openings. C. M. S., JR.

22. Furnace for brick and tile kilns. HALVER R. STRAIGHT. U. S. 1,411,534, April 4, 1922. A fur. for brick and tile kilns comprising a downwardly and outwardly inclined tube through the wall of the kiln, and having means at the lower and outer end for feeding combustible gases, and at its upper and inner end means for mixing the gases as they enter the kiln. C. M. S., JR.

23. Kiln. JEROME B. RIFFLE AND LOUIS H. HARTMAN. U. S. 1,411,871, April 4, 1922. In a kiln as characterized, a flue disposed centrally of the kiln, fur. disposed at opposite sides of the kiln and having heat conducting passages connecting the centrally disposed flue, a heat reflector disposed within the lower portion of the centrally disposed flue and interposed between the opposed ends of the heat conducting passages, exit flues extending radially of the kiln beneath the floor thereof and in communication with the interior of the kiln through openings formed in the floor of the latter, the exit flues having laterally extending branches disposed inwardly of and parallel to the vertical wall of the kiln and in communication with the interior of the latter through openings formed in the floor thereof, stacks spaced around the top face of the vertical wall of the kiln and having the flues thereof extending downwardly within the latter, the lower ends of the flues in the vertical wall of the kiln being arranged in communication with the outer ends of the radially extending exit flues, and dampers operable in the flues of the stacks for controlling the distribution of the heated air in its passage through the kiln from the centrally disposed flue. C. M. S., JR.

24. Foundry sand. A. POULSON AND C. J. ROURKE. Brit. 173,687, Dec. 11, 1920. $Al_2(SO_4)_3$, 37½–45%, 37½–45% of china clay and 10–25% of ground pitch are reduced to powder and thoroughly mixed and incorporated with the sand, water being added to give the necessary dampness. To renovate an ordinary sand which has been burnt completely, about 1 cwt. per ton of sand is added. (*C. A.*)

Apparatus and Instruments

25. Difficulties encountered in the installation of a pyrometer system. R. S. WHIPPLE. *Ceramique*, **25**, 65–70(1922).—A translation of the article which appeared in *Trans. Ceram. Soc.* (1921). H. G. SCHURECHT

26. Routine gas analysis apparatus. R. V. WHEELER. *Gas. J.*, **157**, 702–3(1922); 4 figs.—A simplified adaptation of the Hempel app., which in some respects resembles the Orsat app., is described. The usual 2 sources of error (one which occurs through admittance of a bubble of air when one absorption vessel is detached from the other and substitution made, and the other due to the absence of facilities for washing the gases after treatment with the various absorbents) are eliminated and the app. is made handier in use, by connecting all the absorption vessels and the explosion vessel to the measuring buret by a system of 3-way taps, and by provision of washing facilities. The app. is adapted for the analysis of coal gas and coke-oven gas and gives results sufficiently accurate for routine work. The methods of absorption and explosion are explained and the manipulation is described. Each analysis of coal gas requires about ½ hr. Four sep. analyses can be carried on at once in different stages. J. L. WILEY (*C. A.*)

27. A new X-ray diffraction apparatus. WHEELER P. DAVEY. *J. Optical Soc. Am.*, **5,** 479–93(1921).—An app. is described by which the characteristic X-ray diffraction patterns of 15 powdered crystals may be taken at once. Each pattern is recorded on a strip of photographic film $1^7/_8 \times 16$ in. held in a cassette on the arc of a circle of 8 in. radius, at the center of which is placed the glass tube contg. the specimen. The cassettes are radially disposed on a circular horizontal table at a fixed distance from a vertical H_2O-cooled MO-target Coolidge tube. The tube is excited by a specially designed transformer without rectifiers, placed under the table, thus constituting a complete compact self-contained app. The slit system is of special design for photographic analysis and contains one ZrO_2 filter, while the other filter is built into the cassettes. The time required to obtain satisfactory results varies from 5 to 12 hrs. for substances like NaCl to from 48 to 70 hrs. for CuCl, CsI, etc. The diffraction pattern may be interpreted directly in terms of interplaner distances in the crystal by means of a metal scale calibrated in Å. Graphs are included by means of which the crystal structure may be interpreted directly from the interplaner distances for the cubic, tetragonal and hexagonal systems.
G. L. CLARK (*C. A.*)

28. High-speed high-vacua mercury vapor pumps. C. T. KNIPP. *Science*, **55,** 183–4(1922).—Two high-speed pumps are described. Sketches are given showing the simplicity of construction. The glass used is Pyrex. D. E. SHARP (*C. A.*)

29. Titration apparatus with automatically fixed zero point. ADOLF BRÄUER. *Chem.-Ztg.*, **46,** 117(1922).—The buret has cocks below and above the graduated section, the zero point being at the upper (3-way) cock, above which is a small overflow reservoir. Below the lower cock the buret is drawn to a stem which reaches nearly to the bottom of the stock bottle; the app. is filled by blowing into the bottle, the soln. being withdrawn through a side-tube above the lower cock. J. H. MOORE (*C. A.*)

30. The use of the optical pyrometer in practice. KARL DAEVES. *Stahl u. Eisen*, **42,** 121(1922).—Optical pyrometers suitable for works use are either of the Wanner or Holborn-Kurlbaum type. The latter, in which the intensity of one wave length emitted by the body to be measured is compared with a lamp filament, is the best. In the Wanner pyrometer the light is polarized and its intensity measured by the rotation of the analyzing nicol necessary to make it comparable to a standard illumination. For measurements in a muffle (black body condition) the temp. may be detd. within ± 10° with a pyrometer of the H.-K. type. If measurements are made under other conditions they must be corrected according to the formula $\log e = (C \log E/\lambda)\ (1/T_a - 1/Sa)$, where e is the emissivity of the body to be measured, $C = 14{,}500$, $\log E = 0.4343$, S_a = observed temperature, T_a = actual temp., λ the wave length of the light used in μ. Burgess' values for emissivity are: liquid iron 0.4, liquid iron oxide 0.5, refractories 0.6, liquid slag 0.65. R. S. DEAN (*C. A.*)

31. Draft device for laboratories. M. FISCHLER. *Z. angew. Chem.*, **35,** 43(1922); 1 cut.—A bent pipe or tile is inserted in the stove hole of a chimney. A gas flame in the upper end increases the draft and the lower end is placed over the mouth of the flask to catch the fumes. J. H. MOORE (*C. A.*)

32. Flue gas testers. F. O. H. BINDER. *Chem.-Ztg.*, **46,** 149–51(1922).—Descriptions with cuts, of (1) Schumacher's "Oekonometer," an app. in which the gas is weighed and the change in sp. gr. due to varying amts. of CO_2 is recorded on a chart as % CO_2; (2) Maihack's "Duplex-Mono," by which both the burned and unburned constituents of the gas are detd. alternately, the 1st by direct absorption and the 2nd by absorption after burning in a CuO furnace heated by electricity; (3) the "Union gas tester," which depends on the relative friction resistance of the gas and air when passed through a narrow tube. J. H. MOORE (*C. A.*)

33. 1920 Report of Committee on Pyrometer. W. E. FORSYTHE. *J. Optical Soc.*

Am., **5**, 494–512(1921).—F. redefines brightness temp., color temp., and some less used varieties of temp., gives simple working directions covering the whole subject of optical pyrometry, including construction and the avoidance of certain errors, and adds a brief record of the year's literature on the subject. W. P. WHITE (*C. A.*)

34. New graphic B.t.u. calculator. M. C. K. JONES. *Gas Age-Record*, **49**, 392–4 (1922).—A copyrighted diagram is shown by means of which lengthy calcns. are avoided in connection with lab. calorimeter tests. It may also be used to find correction factors for correcting gas vols. in routine lab. practice, in such tests as the estn. of H_2S, $C_{10}H_8$, CN, etc. It is based upon the general heating value formula. Observed B.t.u. = $[WT/0.2(B - A_t)(460 + 60)] \div [(30 - 0.517)(460 + t)]$, where W = wt. of H_2O heated, T = temp. rise of H_2O, B = barometer in in. Hg, A_t = tension of aq. vapor corresponding to temp. of gas, t = temp. of gas. J. L. WILEY (*C. A.*)

35. Brady B. t. u. indicator tests. O. L. KOWALKE. *Gas Age-Record*, **49**, 405–6 (1922); cf. *C. A.*, **14**, 338, 3781.—Tests were made to det. how accurately the heating value of gas could be measured and how to operate the instrument most effectively. Results were checked against a Sargent continuous flow gas calorimeter. It was found that the Brady app. has the tendency to read too low when the gas becomes richer and too high when the heating value drops from the point when the instrument was standardized. Diluents such as CO_2 and N_2 and combustibles like H_2 and CO have a marked effect on the indications of the instrument. It is not an instrument of precision but will give reasonable approximations when calibrated on a gas similar in heating value and compn. to that which is to be tested. J. L. WILEY (*C. A.*)

36. Brick-making in remote mining districts. H. C. ROBSON. *Mining & Sci. Press*, **124**, 187–91(1922).—Brick making in Siberia is described.

R. R. DANIELSON (*C. A.*)

37. Modern apparatus for the control of combustion and heating. LUCIEN MAUGE. *Bull. soc. encour.*, **133**, 1237–1321(1921).—A more extended discussion of matter treated by Berthelot, *Ceram. Abs.*, **1**, 34(1922). DONALD W. MACARDLE (*C. A.*)

38. Color classification of blast furnace slags. W. G. IMHOFF. *Blast Furnace Steel Plant*, **9**, 433–4(1921); cf. *C. A.*, **11**, 1622, 2877.—The purpose of this paper is (1) to furnish scientific data on "molten magmas" to the geologist and (2) to give the blast-furnace man a complete table of "color classification of blast furnace slags." It is professed to be the first attempt to classify slags scientifically. The analogy between slags and ordinary molten magmas and basaltic lava is emphasized. It is maintained that temp. and slag compn. are functions of one another. C. C. DAVIS (*C. A.*)

PATENT

39. Refractory cover for electric furnaces. MONROE S. CLAWSON. U. S. 1,410, 654, March 28, 1922. In combination with an elec. fur. including a crucible supported between heads, a carriage movable toward and away from the crucible, and a cover for the crucible formed of refractory material and supported by the carriage.

C. M. S., JR.

Chemistry, Physics and Geology

40. Regarding the accuracy of quantitative chemical analyses. E. SELCH AND R. GARSTENAUER. *Sprechsaal*, **54**, 432–43(1921).—The analyses were obtained of the same sand as in table which follows on page 202. Sample I was obtained from the mines while sample II was obtained from a customer. The presence of impurities in II is probably due to storage. Chem. analyses are seldom made which are more accurate than 0.01, and to state the chem. analyses in the third place is misleading. Errors due to impurities in the reagents, to incomplete chem. reactions and to

	I	II
SiO_2	99.85	98.60
Al_2O_3	0.05	0.331
ZrO	....	
Fe_2O_3	0.011	0.010
MgO	....	0.190
CaO	0.01	0.158
CuO	....	0.093
SO_3	....	0.082
S	....	0.018
Na_2O +	0.02	0.220
K_2O	....	.....
Loss on ignit.	0.10	.....
	100.041	99.70

inaccurate weighing would prevent an accuracy of more than one in the second place with the exception of analyses made by calorimetric methods.

H. G. SCHURECHT

41. Physical chemistry of the oxides of lead. III. Hydrated lead monoxide. SAML. GLASSTONE. *J. Chem. Soc.*, **121,** 58–66(1922); cf. *Ceram. Abs.*, **1,** 104(1922).—Expts. of previous investigators were repeated; none of the methods described yield substances having definitely the reported compns., 3 $PbO.H_2O$ or 2 $PbO.H_2O$. The products are either pure 5 PbO.2 H_2O or 8 PbO.3 H_2O or solid solns. of two or more simple hydrated oxides. It was not possible to decide between these alternatives but on the whole the data favor the former. The compn. of the ppt. from a Pb salt soln. by alkali depends on temp. and concn. of the precipitant, probably because of variation in the amt. of adsorbed water. Every prepn. examd. lost water on heating until decompn. set in at a point which was almost identical in every case (3.08–3.13% water). The dissociation const. of $H.HPbO_2$ produced by dissolving hydrated PbO in water was found by methods previously described to be 1.35×10^{-12} at 25°. The hydrated oxides have no appreciable vapor pressure; this and other properties are best explained by the assumption that they are salts of $H.HPbO_2$, *e. g.*, $Pb(HPbO_2)_2$. Attempts to prep. *Ag plumbite* gave a product roughly corresponding to $(AgHPbO_2)_2Ag_2O$. A. R. M. (*C. A.*)

42. A simple method for the determination of melting points and critical temperatures. W. HEIKE. *Z. anorg. allgem. Chem.*, **118,** 254(1921).—Note pointing out accuracy of 814.5– as m.p. of *arsenic*. G. L. CLARK (*C. A.*)

43. Zinc borate. T. C. N. BROEKSMIT. *Pharm. Weekblad*, **59,** 265–8(1922).—Zn is pptd. quant. in a gelatinous form by the mol. equiv. of borax soln. A. W. DOX (*C. A.*)

44. Economic mineralogy. J. A. HOWE. *J. Soc. Chem. Ind.*, **41,** 21–3R(1922).—An instructive address, illustrated by many examples which occurred during the war. Among important problems yet to be solved are: more efficient utilization of fuels, improvement in ore extn., and finding of uses for many minerals containing common or rare elements. L. W. RIGGS (*C. A.*)

45. Analysis of basic slag (citric-soluble P_2O_5). ANON. *J. S. African Chem. Inst.*, **5,** 16–19(1922).—Results obtained by different analysts for the citric-sol. P_2O_5-content of a prepd. sample of basic slag are tabulated for comparison. The official method and other methods were used. The official method consisting in extg. the sample with a 2% soln. of citric acid, pptg. of the P with molybdate, and subsequently with magnesia mixt. S. G. SIMPSON (*C. A.*)

46. Preparation of sols of silicic acid and tungsten hydroxide with the help of the Hildebrand cell. M. KRÖGER. *Kolloid-Z.*, **30,** 16–8(1922).—The sols were prepd.

by electrolyzing solns. of the Na salts using a Hg cathode. The current decreased steadily as the electrolysis progressed. After 2 hrs. electrolysis at 8v. the current in a 1.5% soln. of *Na silicate* (compn. not stated, probably approx. $Na_2O.3SiO$—Abstr.) had fallen to a min. (0.08 amp.). The resulting sol, which was neutral to litmus, set in 4 weeks. When a 6% soln. became neutral, it set rapidly to a clear gel. Hydrated SiO_2 sepd. on the anode and prevented further electrolysis of a 30% soln. The prepn. of a dark brown sol of *lower hydroxides of W* from a 2% Na_2WO_4 soln. was speeded up by the addn. of 0.1 *N* HCl. If any excess of acid were added, *W blue* was formed. A less stable gray sol similar to the brown one resulted when the Pt cathode in the electrolysis of acidified soln. of *pertungstates* was covered with a rubber diaphragm. *Hydroxides of Al, Cr,* and *Mo* pptd. during electrolysis in the *Hildebrand cell.* WM. STERICKER (*C. A.*)

47. The influence of tungstic acid on the gelatinization of silicic acid in strong hydrochloric acid solution. M. KRÖGER. *Kolloid-Z.*, **30,** 18–9(1922).—The *setting time of silica gels* formed by the mixt. of 9.77 *N* HCl and Na silicate soln. (33.7% SiO_2, % Na_2O not stated) was decreased by the addn. of a 10% soln. of $Na_2WO_4.H_2O$. The decrease was not proportional to the amt. of tungstate soln. added. W. S. (*C. A.*)

48. Electroadsorption as a purely chemical phenomenon. I. M. KOLTHOFF. *Kolloid-Z.*, **30,** 35–44(1922).—The adsorption of ions by solids (or the dispersed phase of suspensoids) is regarded as strictly a chem. reaction in which one ion of a very slightly sol. salt is replaced by another ion to form a second difficultly sol. salt. The process is strictly analogous to the exchange of bases in permutite. Freundlich's equation for the adsorption isotherm, $x/m = \alpha c^{1/n}$ (x/m is the amt. adsorbed per unit of adsorbent, c the final concn. of adsorbed ion in the soln., α and $1/n$ consts.) can be developed in which α depends upon the soly. products of the 2 difficultly sol. salts and $1/n$ is inversely proportional to the valence of the adsorbed ion. Data of Freundlich, Odèn, and the author are given to show that the values of $1/n$ for ions with valences of 1, 2 and 3 are as 1: $^1/_2$:$^1/_3$. F. L. BROWNE (*C. A.*)

49. Clay as an ampholyte. O. ARRHENIUS. *J. Am. Chem. Soc.*, **44,** 521–4(1922).—Clay, irrespective of its source, acts as an amphoteric electrolyte. The theoretical and practical importance of this is briefly discussed. H. JERMAIN CREIGHTON (*C. A.*)

50. New method for the volumetric determination of copper. S. MINOVICI AND A. IONESCU. *Bul. soc. chim. Romania,* **3,** 89–93(1921).—The method depends upon the pptn. of $Cu(NH_3)_4SO_4$ by the addition of 8 vols. of alc. to the concd. ammoniacal soln. and the titration of the ppt. with standard H_2SO_4 soln., methyl red being used as indicator. $Cu(NH_3)_4SO_4 + 2\ H_2SO_4 \longrightarrow 2(NH_4)_2SO_4 + CuSO_4$. W. T. H. (*C. A.*)

51. Methods of investigation at the Institute for Colloidal Research in Frankfort a. M. III. Investigation of preparations of colloidal silicic acid. ANON. *Chem.-Ztg.*, **45,** 1249–50(1921); cf. *C. A.*, **14,** 2574.—Prepns. of colloidal silicic acid which are sold for therapeutic use, such as in pulmonary tuberculosis, were investigated. The ultramicroscope furnished no information on the degree of dispersion of sols. of silicic acid. By the use of Kleinmann's nephelometer a relative value for the degree of dispersion was possible. Quant. relations were obtained by ultrafiltration. By this means the mixt. of differently dispersed particles was fractionated and compared with sols. of known degree of dispersion in order to obtain the abs. size of the particles.

H. M. MCLAUGHLIN (*C. A.*)

52. Heat transfer. W. H. MCADAMS AND T. H. FROST. *J. Ind. Eng. Chem.*, **14,** 13–8(1922).—Deals with conduction and convection only. Customary engineering formulas are often faulty; heat transfer is usually through 2 surfaces and a solid body and these 3 parts are differently affected by most changes of condition, hence they must be separately calcd. and not lumped together, as is often done. The leakage at a fluid-solid surface is conveniently treated by referring it to a *film* of the fluid, whose general

characteristics are discussed. New data are given showing the *properties* and *behavior* of this *film* for *condensing steam*. H. F. Weber's rule for the *thermal cond. of liquids* is tested for 13 liquids, and found consistent to 7%. W. P. WHITE (*C. A.*)

53. Rates of adsorption and heat transfer between gases and liquids. W. G. WHITMAN AND J. L. KEATS. *J. Ind. Eng. Chem.*, **14**, 186–91(1922).—The theory of the rate of transfer of heat and absorbable matter between liquids and gases is given, in which it is pointed out that this rate varies directly with the active vol., the driving potential, and the transfer coeff. These transfer coeffs. depend also upon the type of equipment and operating variables, such as gas velocity, liquor rate, etc. Exptl. values for these coeffs. were detd. on several types of equipment. From an economic standpoint, however, other factors must be considered in the design and operation of equipment.

E. N. B. (*C. A.*)

54. Reduced temperatures of transition and of fusion. J. NARBUTT. *Physik. Z.*, **21**, 341–9(1920).—A preliminary paper. By mathematical analysis several relations are developed concerning the phys. state of compds. With the various functions designated by symbols as follows: Θ = abs. temp. of transition or m.p. at the triple point; U_μ = the corresponding heat of fusion and transition; T = the abs. temp. chosen; A_T = free energy of transition; U' = heat of transition; U'' = heat of fusion; Θ' = temp. of transition; Θ'' = temp. of fusion; p_1 = vapor pressure of the solid; p_2 = vapor pressure of the liquid; $\phi = T/\Theta$; R = a const. in the well-known relation $A = RT \log p_2/p_1$ and S = the entropy, there are developed the following relations:
(1) $A'_{T'}/U'_{\Theta'} = A''_{T''}/U''_{\Theta''}$; (2) $U'_{T'}/U'_{\Theta'} = U''_{T''}/U''_{\Theta''}$; (3) $A'_{T'}/\Theta' = A''_{T''}/\Theta''$; (4) $U'_{T'}/\Theta' = U''_{T''}/\Theta''$; (5) $U_\Theta = [2R\Theta\vartheta/(1-\vartheta^2)] \times \log(p_2/p_1)$; (6) $\sqrt{p_2'/p_1'} = S''_{\Theta''}\sqrt{p_2''/p_1''}$; (7) $p_2'/p_1' = p_2''/p_1''$.

C. C. DAVIS (*C. A.*)

55. Determination of surface tension from the rise in capillary tubes. S. SUGDEN. *J. Chem. Soc.*, **119**, 1483–92(1921).—In the detn. of surface tension from the rise in capillary tubes, it has been considered necessary to use a reference tube sufficiently large to give a plane surface. S. used two small tubes of different diameters and calcd. the surface tension from the difference in the heights of rise in the two tubes. The equation is $2\gamma[(1/b_1) - (1/b_2)] = Hg(D - d)$ where γ is the surface tension, b_1 and b_2 are the radii of curvature of the lowest points of the two menisci, H is the difference in level of the lowest points of the two menisci, g is the acceleration due to gravity and $(D - d)$ the difference between the density of the liquid and that of the surrounding medium. A table of corrections for use with this method is given and its use explained. The method is accurate to about 0.3%. The advantage of the method is that only small quantities of liquid are required. F. E. BROWN (*C. A.*)

56. The law of distribution of particles in colloid solution. E. F. BURTON AND MISS E. BISHOP. *Proc. Roy. Soc.* (London), **100A**, 414–9(1922).—After a Cu colloidal soln. was allowed to stand undisturbed for 50 days in a room which varied little in temp., the Cu was found to be uniformly distributed throughout the body of the liquid. These expts. indicate that the variation in concn. at different depths expressed in Perrin's distribution law must be confined to a very small distance at the surface.

H. M. McL. (*C. A.*)

57. General conditions of the validity of the principle of Le Chatelier. A. J. LOTKA. *Proc. Am. Acad. Arts Sci.*, **57**, 21–37(1922).—By a general method of proof not depending on the laws of energy but only on considerations involving rates, it is proved that for isolated systems of const. mass the principle of Le Chatelier holds if the addn. of a small amt. of a component disappearing in the transformation of the system, or the subtrac-

tion of a small amt. of a component increasing in the transformation, increases the rate of the transformation. If the reverse is true, Le Chatelier's principle does not hold. This condition takes a somewhat more complicated form in case outside forces are active.

F. R. B. (*C. A.*)

58. Theory of adsorption processes. A. EUCKEN. *Z. Elektrochem.*, **28**, 6–16(1922).—A theoretical study and mathematical analysis of adsorption phenomena and adsorption curves. This method offers a commensurate and direct means of ascertaining the action between different mols. The results of Langmuir's investigation of the adsorption of gases by glass, mica and Pt (cf. *C. A.*, **12**, 2152) are discussed at length.

H. JERMAIN CREIGHTON (*C. A.*)

59. A new iodometric method for the determination of copper. R. LANG. *Z. anorg. allgem. Chem.*, **120**, 181–202(1922).—The usual iodometric detn. of Cu depends upon the reduction of Cu by iodide and titration of the I_2 that is liberated. The new method depends upon the oxidation of $Cu_2(SCN)_2$ by standard I soln. and titration of the excess of I with $Na_2S_2O_3$, the cupric ions being removed by the formation of Cu-oxalate complex which is not reduced by iodide under the prevailing conditions. Two methods for carrying out the analysis are described. (1) To the soln. contg. not more than 0.28 g. Cu and a little mineral acid, add an excess of H_2SO_3 and of 0.1 *N* KCNS until all the Cu is pptd. as $Cu_2(CNS)_2$. Boil off the excess SO_2, cool, add 120–150 cc. of an oxalate mixt. prepd. by mixing 5 vols. of 0.32 *N* $(NH_4)_2C_2O_4$ and 7 vols. of 0.95 *N* $H_2C_2O_4$ and dil. to about 400 cc. While rotating the contents of the Erlenmeyer flask, add 0.1 *N* I soln. until the cuprous ppt. is entirely dissolved and then titrate the excess of I_2 with $Na_2S_2O_3$ soln. (2) To the Cu soln. in a long-necked flask, add NH_4OH until ammoniacal and discharge the color with 0.5 *N* KCN soln. Add 1 g. of NH_4CNS and, while cooling, make the soln. acid with 0.95 *N* $H_2C_2O_4$ soln., which causes the pptn. of $Cu_2(SCN)_2$ to be analyzed as in Method 1. Method 1 is applicable in the presence of all cations which are not reduced to metal by H_2SO_3. Method 2 is applicable in the presence of all other metals with the following modifications: *Ag.*—The pptn. of AgI tends to prevent the dissolving of the $Cu_2(SCN)_2$ so that the contents of the flask should be shaken a long time before titrating the excess of I_2. *Hg.*—In many cases it is necessary to add additional NH_4CNS to dissolve HgI_2. *Pb.*—The pptn. of $PbSO_4$ is prevented by $AcONH_4$ and by using AcOH instead of $H_2C_2O_4$. First add Rochelle salt to the Cu soln., make strongly ammoniacal, decolorized with KCN, add NH_4CNS and acidify with AcOH. *Bi.*—Proceed as with Pb but acidify with oxalic acid and shake well before the final titration. *As.*—Acidify with AcOH. *Sb.*—Make the soln. strongly ammoniacal, add $(NH_4)_2C_2O_4$ or $Na_4P_2O_7$ and heat to convert the quinquevalent Sb into a sol. complex. Then proceed as with Cu alone. *Co.*—After the decolorization with KCN boil to decompose the H_2O_2 formed during the production of the complex $Co(CN)_6^{---}$. *Mn.*—Instead of adding NH_4OH, it is necessary to add Rochelle salt or $(NH_4)_2C_2O_4$ to prevent pptn. of $Mn(OH)_2$ and to avoid an excess of KCN. *Ba*, *Sr*, *Ca* and *Mg* may give ppts.; these will not form, however, if an excess of Rochelle salt is used instead of NH_4OH and AcOH is used instead of oxalic acid; the soln. should be well shaken before the final titration.

W. T. H. (*C. A.*)

60. Volumetric and gravimetric determination of zinc. S. URBASCH. *Chem.-Ztg.*, **46**, 97–99, 101–3, 125–7, 133–4, 138–9(1922); cf. *Ceram. Abs.*, **1**, 174(1922).—As a result of a critical study of the various methods commonly used for the detn. of Zn, the following procedure is recommended: Treat 1.5 g. of the finely powdered ore in a 300-cc. beaker with 20 cc. of concd. HCl. Heat until disintegrated, add 3 cc. or less of concd. HNO_3 and again heat. Add 16 cc. of 18 *N* H_2SO_4 and heat on the sand bath until nitrous fumes are all expelled and most of the HCl is evapd. Add HF drop by drop until the SiO_2 gel is all dissolved and then evap. to fumes. Cool, add 60 cc. of water and digest about 15

min. at 60–70°. Sat. with H_2S, filter and wash with a mixt. of 80 cc. hot water, 2 cc. 18 *N* H_2SO_4 and 20 cc. of satd. H_2S soln., using this wash liquid in 10–15-cc. portions. The filtrate should not exceed 180 cc. Boil off H_2S, adding a little coarse sand to prevent bumping. Add 3–5 cc. of H_2O_2 to oxidize the Fe and heat 5 min. to remove excess of oxidizer (if Mn is present add 0.5–2 g. of Br. and shake). Add 20 g. NH_4Cl and an excess of NH_4OH. Make up to exactly 300 cc., filter and use 100 cc. of the filtrate (0.5 g. of ore). Evap. gently until all the NH_4OH is expelled, add 1 drop of methyl orange and neutralize carefully with HCl. Heat to boiling, dil. to 150 cc., add 3 cc. of $FeCl_3$ soln. contg. 0.1 g. of Fe per 1. and titrate the hot soln. with $K_4Fe(CN)_6$ until the blue color changes to white, and then titrate back to a pale blue with standard Zn soln. In the study of the gravimetric detn. of Zn, no attention was paid to the detn. as phosphate. The expts. showed, however, that it is possible to ppt. Zn quant. as ZnS from a soln. originally neutral and contg. as much as 3.1 g. of $ZnCl_2$ or 7.5 g. of $ZnSO_4$. If the soln. contains 1 cc. of *N* HCl per 100 cc. and from 0.15 to 0.2 g. of Zn the pptn. as ZnS is quant. and the ppt. easy to filter. The presence of NH_4 salt appeared to retard the pptn. Satg. with H_2S in the cold and then heating the stoppered flask to about 40° served to aid pptn. The presence of Al retarded the pptn. of ZnS but pptn. in the presence of HCOOH seemed to be favorable as has been found by others. W. T. H. (*C. A.*)

61. The form of silicon: Solubility of silicon in hydrofluoric acid. W. MANCHOT AND H. FUNK. *Z. anorg. allgem. Chem.*, **120**, 277–99(1922); cf. *C. A.*, **16**, 1055.—Alloys of Al-Si were prepd. in the form of reguli by heating Al with K_2SiF_6, and dilg. with Al, or by direct fusion of Al and Si. Samples were then heated to various temps. for 15–20 min., and one series allowed to cool in the furnace as slowly as possible, another series being poured into H_2O to secure instant cooling. Al was dissolved out by HCl, the residue dried at 80° and weighed, giving the % of Si, and the latter then treated at 120° with 40% HF in a closed Pt vessel, with side tubes for introducing CO_2 and for carrying off the H evolved. Detns. of H showed that from 1.9 to 47.5% of the theoretical vol. of gas was formed, based on the % of Si in the sample, when the melts had been quickly cooled, and that only from 0 to 6.5% of the theoretical vol. of H came from slowly cooled samples. The latter were graphitic, and bluish gray, the single crystals being steel blue or slate blue, and yellowish brown in thin sections by reflected light. The quickly cooled samples were blackish gray, with a brownish tone, and showed no crystn. with a magnification of 960 diams. In water some of the particles showed the Brownian movement, having a diam. of 1 μ or less. A few quickly cooled specimens showed incipient crystn., probably due to the fact that the quenching was occasionally delayed slightly. Melts contg. less than 10% of Si gave more H than more concd. melts. Heating to different temps. had little effect. Very fine pulverizing of both sorts of Si caused a slightly increased H vol., but when the crystd. variety was reduced to particles about 1 μ in diam., the action of HF was still slight. No samples were completely sol. in HF. Amorphous Si left a brown residue which was only slightly attacked on subsequent exposure. All 3 varieties were also slightly attacked by H_2O, the amorphous samples giving up to 1.1% of H, and the crystd. samples only traces. The insol. residue from the amorphous variety was a very reactive brown powder, burning when heated in air or O, igniting with fuming HNO_3, Cl and Br, and giving H with dil. NaOH. This behavior is due to traces of occluded H, which can be driven off at a dull red heat, leaving a dark residue which resumes its brown color on cooling, but which has lost its reactivity. Heating *in vacuo* gave 32–44 cc. of H per g. The brown variety is best prepd. from melts contg. 10% of Si. D. of a quickly cooled sample 2.23, d. of brown variety 2.2, d. of crystd. variety 2.3. The best method for the *detn. of Si content* was found to be measurement of the H evolved on treatment with boiling KOH soln., the gas being driven over by CO_2. Amorphous samples contained 75–88% of Si, some-

what less than the crystd. variety, and slightly more SiO_2, produced by removing the melts from the furnace and quenching. The residue after treatment of the amorphous Si and HF also contains some SiO_2, evidently produced by cyclic reactions involving SiF_4 and H_2O. When 25 g. of crystd. Si was treated 21 times for 4 hrs. each with HF, the wt. was reduced to 2 g., the crystals lost their luster, and the residue was an almost amorphous powder, which, however, under the microscope still showed crystal forms. Consequently even crystd. Si is slowly but practically completely sol. in HF. Moissan and Siemens (*Ber.*, **37,** 2540(1904)) prepd. crystd. Si from Ag melts, which was 99% sol. in HF, and formed thin yellow transparent or translucent plates. But M. and F, found that black crystd. Si from slowly cooled Ag melts gave very little H with HF, while quenched Ag melts gave completely amorphous Si which easily evolved H. M. and S. state also that the rapidity of cooling has no influence on the yield of Si sol. in HF, and do not appear to have noted that H is formed. Their high Si contents were probably due to their method of analysis, which consisted in dissolving the samples in 10% KOH and weighing the SiO_2 formed, no statement appearing as to a correction for the SiO_2 already present. M. and S. apparently did not prep. the amorphous Si formed in rapidly cooled Ag melts. To test M. and S.'s statement that melts containing not more than 2% Si gave a product completely sol. in HF, 2 melts containing 2 g. of pure Si and 50 g. of Ag were prepd., heated to 1500°, one of them cooled slowly, and the other poured in H_2O. Each gave, after soln. of Ag in dil. HNO_3, 0.5 g. of Si. That from the quenched melt was a very voluminous brown powder, showing no crystn. under a magnification of 960, and agreeing in properties with that prepd. from Al melts. The slowly cooled melt gave a much less voluminous gray, cryst. powder. Heated in HF for 1 hr. at 120°, the amorphous Si, 70% pure, gave 15.1% of H, while the cryst. powder, 85.2% pure, gave only 8.2% of H. Expts. with Zn and Pb melts (with O. KÖHLER) also gave amorphous Si which was more reactive than the slowly cooled cryst. form, but the amt. of H evolved with HF was relatively lower than in samples formed in Al or Ag melts, owing to the lower soly. of Si in Zn and Pb, which favors crystal formation even with rapid cooling. Si prepd. by Kühne's method from SiO_2, Al and S, after treatment with boiling HCl to remove Al, was crystd. and gave only 2.7% of H. Technical massive Si gave 3% of H when quenched in H_2O from 2000°, and 2.1% when slowly cooled, and similar results were obtained with pure Si, all the samples being crystd. after cooling. Amorphous Si, both before and after treatment with HF, can be changed into crystd. Si by soln. in Al. So-called "amorphous" Si prepd. by reduction of quartz with Mg gave very little H, and the microscope showed it to be cryst. M. and F. conclude that their amorphous Si is not an allotropic modification, but is an extremely finely divided form of crystd. Si, which cannot be produced by mech. means, although it can be approached by fine grinding. The brown amorphous variety, which is resistant to HF, is thought to possess a kind of passivity due to the occluded H. M. R. SCHMIDT (*C. A.*)

Refractories and Furnaces

62. Apparatus for the determination of deformation of refractories under load. DR. W. STEGER. *Ber. der. Deut. Keram. Gesellschaft,* **31** (1922).—The writer reviews previous methods of testing refrac. under load and describes his app. This app. is independent of the fur. and is portable. Heat is obtained elec. and the expansion or contraction of the specimen is recorded automatically. R. F. G.

63. Silica brick of constant volume. O. REBUFFAT. *Trans. Ceram. Soc.*, **21,** Pt. 1, 66–68(1921–1922) (R. Rieke).—The writer gives data showing effect of small percentages of P_2O_5 on the inversion of quartz to tridymite. It is shown that 0.31–0.45% P_2O_5 is sufficient to effect a lowering of the sp. gr. from 2.65–2.60 to 2.25–2.30 in a single burn of 8 hours at 1300–1350°C. R. F. G.

64. Behavior of refractory brick under load at high temperatures. DR. K. ENDELL. *Trans. Ger. Ceram. Soc.*, **2,** 73(1921).—Cylinders of refrac. material 2″ diam. and 2″ high are heated to 1700°C in an elec. resist. furnace and pressure is applied by means of a suitable lever arrangement. Four different types of refrac. tested in this way compare as follows: 1. *Clay Brick*—Initial softening point about 1300° C. If plastic clay content is high may be lowered to 1150° C. 2. *Magnesite Brick*—Initial softening point about 1500° C. 3. *Silica Brick*—Short softening range commences about 1650° C and shortly thereafter collapses, whereas magnesite brick even at 1700° C. still shows a certain degree of stability. 4. *Carbon brick*—No signs of softening up to 1700° C.

F. A. WHITAKER

65. The development of a new refractory. A. F. GREAVES-WALKER. *J. Soc. Chem. Ind.*, **41,** 13–14T(1922).—Quantity production of sillimanite brick has already commenced. Analysis of brick is: SiO_2, 6.32; Al_2O_3, 86.10; Fe_2O_3, 1.17; CaO, 0.60; alkalies 1.10; TiO_2, 4.53%. Pure sillimanite is 37 SiO_2, 63 Al_2O_3 with fusion temp. at 1816°. The brick compare favorably with SiC under the same conditions.

R. R. DANIELSON (*C. A.*)

66. Retorts for zinc ores. J. P. VARIAN. *Eng. Mining J.*, **113,** 363(1922).—V. recommends sizing of grog to minimize voids. Each grain of grog must be coated with a thin film of clay and to accomplish this the clay is soaked with H_2O in a large tank to form a thin mud. The tank should have a mixing device and sized grog should be added in definite amts.

R. R. DANIELSON (*C. A.*)

67. The determination of the thermal conductivity, specific heat, density and thermal expansion of different rocks and refractory materials. Y. TADOKORO. *Science Repts. Tôhoku Imp. Univ.*, **10,** 339–410(1921).—This extensive report covering 109 specimens of Japanese and Asian rocks and refractory materials contains 18 tables and 45 figures. For detg. the thermal cond. the test-specimen is periodically heated and cooled and the penetration of the temp. wave into the interior measured, the diffusibility being calcd. by means of Fourier's series. A purely sinusoidal heat source was devised using a variable resistance in a plectrum form. This and the methods for the other properties are described in great detail. The cond. increases with content of magnesia, but decreases with that of silica, lime and alumina. Densities are calcd. from the coeffs. of expansion. Silica bricks are most suitable for installation of a reservoir of heat, the temp. of which is required to rise as quickly as possible when hot gas comes into it, and to cool quickly when cold air comes in. Chamotte bricks are most suitable for thermal insulation.

G. L. CLARK (*C. A.*)

68. New seven-ton Heroult furnace. ANON. *Iron Age*, **109,** 325(1922).—The furnace described departs from the standard types, in that the lift of the electrodes is extremely high and makes possible the use of mech. charging devices.

LOUIS JORDAN (*C. A.*)

69. Acid open-hearth process for manufacture of gun steels and fine steels. W. P. BARBA AND H. M. HOWE. *Trans. Am. Inst. Mining Eng.*, sep. No. **1114-S,** 39 pp. (1922); *Blast Furnace Steel Plant*, **10,** 183–91.—Report of the Committee on Steel Ingots of the Engineering Division of the Natl. Research Council. The paper is a detailed description of the best practice in steel melting and ingot production. It was prepared in order that the number of efficient makes of steel for guns, shells, crankshafts and other forgings might be increased to meet gov't needs in 1918. Publication has been delayed. Reasons are given for each step recommended for the production of sound, clean and uniform ingots of proper structure and for prolonging the life of the furnace. The report is a concise manual which will be of great value to all who wish to make fine steel. Means for restraining segregation, columnar crystn., retention of inclusions, and for preventing internal and external cracks or flakes are given. The advantages of cool

over hot pouring are stated. Ingot mold design is treated in detail. The reasons for the use of top or bottom pouring are clearly stated. The time-temp. diagram on p. 8 and the ingot mold data on pp. 31–39 are important parts of this excellent manual.

JAS. O. HANDY (*C. A.*)

70. Reduction of fuel wastes in the steel industries. F. G. CUTLER. *Mech. Eng.*, **44,** 237–8(1922).—Formulas are given for the calcn. of blast required and gas obtainable in the iron blast-furnace operations. The volume of gas possible = 71.4 *R*, in which *R* is lbs. of coke per t. of pig iron, the B.t.u. value of the gas = 62.5 ÷ 0.0165 *R* and the cu. ft. of air per lb. of coke = 51.4 *R*. The wastes such as the gas and coke braize are utilized at the plant. The gas from the furnace is burned under the boilers and used for the heating of the stoves, the gas from the coke plant is sold and the tars and oils recovered are used as fuel for the open-hearth furnaces, the coke braize is used as a cover for the molten metal when being transported from place to place about the plant. A heat balance for the manuf. of 1 t. pig iron is outlined which shows a total of 17,375,000 B.t.u. required. W. A. MUELLER (*C. A.*)

71. Zirconium and zirconium oxide. L. ANDRIEUX. *Industrie chimique*, **8,** 478–81 (1922).—A review of the occurrence, properties, and applications of ZrO_2, and of the prepn., properties, and applications of Zr, with a bibliography of 21 references.

A. P.-C. (*C. A.*)

72. Calculation of working temperature in metallurgical furnaces. HUGO BANSEN. *Stahl u. Eisen*, **42,** 245–53, 291–7, 370–5, 423–6(1922).—The ratio of the actual working temp. of a furnace to that calcd. from the heat input and the heat capacity and temp. of the products of combustion is 0.65–0.80°. For the heat to be transferred from the flame to the work a temp. difference of 50–300° is necessary. R. S. DEAN (*C. A.*)

73. The present status of electric furnaces in steel making. HARRY ETCHELLS. *West Scotland Iron & Steel Inst.*, **29,** part 2, 2–12(1921).—A review. The many advantages of elec. steel are emphasized. Discussion by Jefferson, Sharpe, *et al.*

C. G. F. (*C. A.*)

74. Aluminium. P. H. SAMPELAYO. *Bol. del. inst. geol. de España*, **41,** 3(1921); *Bull. Imp. Inst.*, **19,** 233–6.—Various deposits of bauxite are described. The bauxite problem in Spain is still under investigation. The % of SiO_2 is high so that the mineral can be used only for obtaining $Al_2(SO_4)_3$, as a refractory or as a building stone. A typical analysis is: SiO_2 9.40, TiO_2 0.96, Fe_2O_3 7.0, Al_2O_3 68.19, CaO 0.4, MgO 0.10, loss 14.10%. R. L. SIBLEY (*C. A.*)

75. A new electric muffle furnace for temperatures up to 1700°. K. ENDELL. *Z. angew. Chem.*, **35,** 31(1922).—The oven is 285 × 185 × 110 mm. inside, uses a.c. or d.c., can be heated to 1700° in 2 hrs. and held within 10° of any desired temp., the temp. is uniform, the power required is 5–16 kw., and repairs are easily made.

J. H. MOORE (*C. A.*)

76. Laboratory furnace for deformation temperature of refractories. L. R. OFFICE. *Chem. Met. Eng.*, **25,** 162–3(1922).—A small pot furnace is described with drawings. Natural gas at $2^1/_2$ lbs. and preheated air at 25–30 lbs. pressure will give cone 35 in 45 min. The preheater and burner are the special features. R. J. MONTGOMERY (*C. A.*)

77. American coking practice. J. W. LEE AND G. A. HEBDEN. *Iron & Coal Trades Rev.*, **104,** 310–11(1922); *Gas World*, **76,** No. 1963 (Coking Sec.), 10–14.—An account of a 2-months' tour in the U. S. visiting 25 coking plants. J. L. W. (*C. A.*)

78. Refractories source of troubles. M. L. MORRISON. *Foundry*, **50,** 33–5(1922).—The blow holes in cast iron attributed to overheating may, in some cases, be caused by the decompn. by water present in the molding sand of carbides of Al and Ca formed by reactions between the melt and the refractories. Careful selection of the refractories used in the cupola lessens this damage. F. P. FLAGG (*C. A.*)

PATENTS

79. Refractory brick. GEORGE A. BALZ. U. S. 1,410,729, March 28, 1922. A refrac. brick consisting of a body portion and a facing portion rel. shaped to mech. engage one another and united only by such engagement. C. M. S., JR.

80. Refractory brick. J. A. WRIGHT. Can. 215,847, Feb. 14, 1922. Refractory bricks are made from natural deposits of chromite and serpentine rock by crushing, agitating with slight moisture to distribute the serpentine particles evenly throughout the chromite and then burning in a kiln. (*C. A.*)

81. Electric furnaces. A. E. REID. Can. 215,822, Feb. 14, 1922. A furnace especially adapted for making *carbide* has an outlet in the furnace chamber which is kept in its open or delivering condition by passing current through an electrode placed in the outlet. Means for feeding a charge to the furnace and electrodes for delivering current to the charge are provided. (*C. A.*)

82. Refractory composition. DANIEL ELIJAH COLLINS. U. S. 1,411,842, April 4, 1922. A refrac. bonding and glazing compn. comprising fire clay, a hydraulic cement and a metallic sulfide. C. M. S., JR.

Stoneware, Whiteware and Porcelain

83. Making of stanniferous faience. ALIX. CORNILLE. *Rev. Mat. Constr. Trav. Pub.*, **150,** 35B–38B(1922).—General description of the body and glazes from the points of view of compn. making, and burning, for faience containing tin oxide. The body is usually a mixt. of clay, an argillaceous marl, and an argillaceous or calcareous sand. Compn. limits are SiO_2 55–65%, Al_2O_3 13–20%, Fe_2O_3 2–4%, MgO CaO 13–25%, KNaO 2–4%. A lime content less than 14% gives rise to cracking, that higher than 22%, to scaling and staining. The propn. of lime is influenced by the content of other bases, *i. e.*, MgO, alkalies and Fe_2O_3; their presence necessitating a decrease in CaO. Also the higher the temp. of burning the lower should be the lime content. A glaze corresponding to $\left.\begin{matrix}0.59\ PbO\\0.40\ Na_2O\end{matrix}\right\}$ 0.15 Al_2O_3, 0.26 SnO_2, 2.45 SiO_2 will stand cone 011. For colored glazes, a mixt. of 1 part of tin glaze and 4 parts of transparent glaze is used as the base, the coloring oxides being added or fritted to the one or the other as the case may require. The formula of the clear glaze is

$$\left.\begin{matrix}0.2\ KNaO\\0.1\ CaO\\0.65\ PbO\end{matrix}\right\}\quad\left.\begin{matrix}0.2\ B_2O_3\\0.1\ Al_2O_3\end{matrix}\right\}\quad 1.1\ SiO_2$$

A clear *tin-less opaque glaze* with which good results have been obtained corresponds to the formula

$$\left.\begin{matrix}0.8\ RO\ (Pb, Ca, Mg)\\0.2\ R_2O\ (K,Na)\end{matrix}\right\}\quad\left.\begin{matrix}0.22\ B_2O_3\\0.07\ Al_2O_3\end{matrix}\right\}\quad 2.08\ SiO_2$$

LOUIS NAVIAS

84. Testing porcelain, kaolin and clay for whiteness. DR. W. FUNK, *Trans. Ger. Ceram. Soc.*, **2,** 39(1921).—The nearest approach to a "standard white" surface which reflects 100% of the light rays can be prepd. from precipitated barium sulphate. For comparing "whites" a "grey" scale of color strips ranging from "standard white" to black is described. This scale is in the form of a long stencil strip with cut-outs between the bands of shades and can be placed over the piece until the shade of the test-piece corresponds with that of the strip. Percentage of "white" in a yellow tinted piece can be determined with the same scale if filtered light is used. Percentage of "white" in porcelain ranges from 70 to 95%. F. A. WHITAKER

85. Handling Equipment. U. SAUER, *Trans. Ger. Ceram. Soc.*, **2,** 66(1921).—Describes advantages of monorail system and gravity elevator for handling raw and finished materials, also a portable conveyor for handling saggers in and out of kilns.
F. A. WHITAKER

86. High fire porcelain glazes. H. H. SORTWELL. *Brick and Clay Record*, **60,** 622–625(1922). H. G. SCHURECHT

87. Comparison of cold glazes and cold glazed tile with ceramic wall tile. C. TOSTMAN. *Ber. der Deut. Keram. Gesellschaft*, **3,** Pt. 1, 31(1922).—T. gives short résumé of patents on cold glazes and of previous lab. tests of this material. Objects to term *glaze* for this product which is composed of Portland cement, color and a lime soap. The tile are prepared by coating a concrete base with this paint. T. gives detailed description of tests and data obtained by detn. of porosity, resistance to freezing, transverse strength, impact test, resistance to chem. and hardness of glaze on both the concrete and ceramic wall tile. The ceramic tile were the usual product of white burning body and translucent glaze. From his own and previous exp. the writer concludes that the cements are a possible substitute for common oil paints as a wall covering but that they are inferior to ceramic tile in every way. The writer expresses his fear that the cheapness and ease of manuf. of this substitute product will lead to its being placed on the market in such quantity as to hurt the wall tile industry. R. F. G.

88. The testing of porcelain. DR. R. RIEKE AND DR. M. GARY. *Ber. der Deut. Keram. Gesellschaft*, **3,** Pt. I, 5(1922).—Growing importance of tests is noted and history given of the formation of a committee, as a branch of the Ger. Soc. of Testing Materials, for the adaptation of standard tests to the study of porcelains (especially elec. porcelain). Detailed descriptions of tensile, ball compression (cold), transverse and impact bending tests are given together with a tabulation of results obtained on eight porcelains. The reliability of the tests are calcd., their comparative value as means for differentiating porcelains found, and the conclusion reached that the ball compression test be further developed as a means for classifying elec. porcelains. Absorption tests (American method of dye penetration) produced no positive results but a modified method was adopted because of the use of this test in other countries. Porosity (both open and closed pores) and the microscopic structure of the eight porcelains were also studied. It was found that altho no definite reln. existed between mech. strength and microscopic structure there was sufficient connection to warrant further study in order that microscopic analyses might be established as a definite and simple means of classifying porcelains. R. F. G.

PATENT

89. Ceramic insulating material. JOSEPH A. JEFFERY. U. S. 1,409,953, March 21, 1922. The raw batch of a ceram. material comprising a mixt. of sillimanite, a flux and a clay mixt., the clay content, when heated by itself, maturing at the temp. at which the ceramic body matures. C. M. S., JR.

Art and Design

90. A proposed standard method of colorimetry. H. E. IVES. *J. Optical Soc. Am.*, **5,** 469–78(1921).—A spectrophotometric method of color measurement is suggested, which consists in measuring adjacent patches of the spectrum, each patch being of width inversely proportional to the hue perception sensibility of the eye at that point and so narrow that no significant color difference can enter because of differences of intensity distribution in the spectra of the compared colors. The advantages over the 3-element methods or other spectrophotometric processes are discussed. As an instrument the principle of the Maxwell color box is used, with specially designed slits. Light from the surface whose color is to be measured, and from a standard white surface under

the same illumination passes through the special slits and 2 lenses placed at their focal distances from the slits. Next is placed a compound photometric prism designed to reflect the light from one lens through one part of the field as viewed by the eye of the observer, and light from the other lens through another part, the dividing edge being as fine as possible. Finally, in order, are a dispersing prism or grating, telescope lens, and narrow viewing slit. To make a photometric match a variable aperture sector is placed before the white-light slit, and the process of making a measurement consists in isolating the successive monochromatic patches, and for each one varying the sector transmission until photometric match is obtained. The method of plotting the results and of reproducing the measured color by a spectrum template disk are fully discussed.

G. L. CLARK (*C. A.*)

91. The use of secondary reference standards in process problems of color measurement. H. S. BUSBY. *Proc. Am. Soc. Testing Materials*, **21**, 1139–53(1921).—A *colorimeter* is described which uses rotating sectors of suitable standard colors or white, similar to the Howland color photometer (*C. A.*, **10**, 2164), but in which the abs. or relative areas of the sectors may be varied or read off while the machine rotates. Color matches may, therefore, be made very rapidly; duplicate measurement agree within sector areas to 0.1% of the total sector circle. For commercial work, secondary reference standards are sufficiently accurate and more easily applied than fundamental standards.

F. A. WERTZ (*C. A.*)

92. Dark colored pipe from fire clay. ANON. *Brick and Clay Record*, **60**, 546(1922).—To aid in bringing about the dark colored pipe alternating oxidizing and reducing conditions should be used. A dull black glaze has been made by mixing crude oil with the salt. The fire immediately before salting should be clear and bright. After the salting the kiln should be fired with reducing conditions, and then oxidizing before salting again. If this scheme is followed several times it facilitates the formation of desirable dark glazes.

H. G. SCHURECHT

93. Battle of the bricks. ANON. *Brick Pottery Trades Jour.*, **30**, 84(1922).—It is claimed by G. Skipper that houses where masters of architecture are found are made with unburned brick since they make the house warm and dry. A. B. Searle questioned the above statements and thinks burned brick are better than unburned.

H. G. SCHURECHT

94. Some ways of reducing the cost. ANON. *Clay Worker*, **77**, 40–42(1922).—Time saving devices for handling the crude clay and ware are described.

H. G. SCHURECHT

95. Paving brick variety simplified. ANON. *Clay Worker*, **77**, 38(1922).—The National Paving Brick Manuf. Assn. in coöperation with Depart. of Commerce of the U. S. and through conference with a number of organizations has been eliminating useless sizes and varieties in paving brick and simplifying standards reduced to the smallest practical number. The varieties to be retained are as follows: Plainwire-Cut Brick, Repressed Lug Brick, Vertical Fibre Lug Brick, Wire-Cut Lug Brick, and Hillside Lug Brick.

H. G. SCHURECHT

96. Preference for asphalt filler for brick pavements for general use is announced. ANON. *Clay Worker*, **77**, 38(1922).—The N. P. B. M. A. adopted asphalt filler for general use as a filler for brick pavements.

H. G. SCHURECHT

97. The determination of the porosity and resistance of clay ware to acids. O. KALLAUNER AND J. FISER. *Sprechsaal*, **54**, 412–422(1922).—The results of porosity and acid tests on 25 different ceram. bodies are given as detd. by different methods.

H. G. SCHURECHT

98. The use of $BaFl_2$ to prevent scumming. ANON. *Sprechsaal*, **54**, 547–548(1921).—Reference is made to Lovejoy's and Staley's work in *Trans. Amer. Ceram. Soc.*, **8**,

255, 17, 200. Using $BaFl_2$ in the place of other barium salts is cheaper, is more sol. than $BaCO_3$, the necessary amt. is the same or less, it does not affect the color of the fired ware, an excess does not cause scumming and it facilitates the vitrification of the mass. H. G. SCHURECHT

99. Burning with oil in Haigh kiln. HAIGH. *Brick and Clay Record*, **60**, 546–547 (1922).—The saving in fuel depends on the cost of fuel oil. Whether it is cheaper than coal or not depends on where it is being used and how cheap oil is compared with coal. The Phenix Clay Corp. use 14 gals. per 1000 brick. The Salmon Brick & Lumber Co., Slidell, La., use $52^1/_2$ gals. per 1000 brick and fire to cone 14, but they top fire with 70 bs. of fine coal per 1000 brick. H. G. SCHURECHT

100. Scumming, efflorescence and whitewash. ANON. *Brick and Clay Record*, **60**, 602–606(1922).—The causes of scumming may be (1) sol. salts in weathered clay, (2) minerals in unweathered clay which decompose, (3) sol. salts in tempering water, (4) sulphur in lubricating oils, (5) sulphur in kiln gases used for dryer heating, (6) slow drying, (7) condensation in dryer, (8) decomposition of sulphur minerals in clay during burning, (9) sulphur from fuel uniting with lime in clay, (10) condensation during water-smoking period, (11) storage on cinders or damp soil, (12) soaking of brick wall and reëlaboration, and (13) action of rain and sol. salts from mortar.

Suggestions for preventing white wash are (1) use freshly mined unweathered clay, (2) weather clay thoroly to enable washing out of sol. salts, (3) be careful as to tempering water, (4) use barium compds. to ppt. sol. salts, (5) dry ware rapidly, (6) prevent condensation in dryer, (7) do not use sulphurous gases in dryer, (8) water-smoke ware uniformly with good draft, (9) use a low sulphur fuel, (10) burn with alternating reducing and oxidizing conditions, (11) coat brick with coal tar or wheat flour, (12) burn brick hard and make impervious, (13) store brick on planks and (14) be careful in use of mortar. H. G. SCHURECHT

101. Schinkel's Berlin brick buildings. H. MACKOWSKY. *Tonind. Ztg.*, **46**, 307–309(1922).—M. describes various types of brick buildings built by Schinkel. H. G. SCHURECHT

102. Observations on burning. J. P. WILLIAMS. *Clay Worker*, **77**, 34–35(1922).—Two types of continuous kilns are described, one in which the fire moves and the ware remains still and the other in which the ware moves and the fire stands still. The ones in which the fire moves are divided into two classes, the compartment type and the tunnel type. The moving ware kiln is divided into two classes, one with a muffle and one without a muffle or what is called direct fired. The moving fire type of kiln is cheaper than the compartment type and the latter is considered better than the tunnel type, although in some of the kilns of the Hoffman type, in which the ware is fired from both top and sides, they get very good results, with but few light brick and over burnt ones. The German and English Hoffman kilns are commonly used in this country and are the best types of the straight tunnel kilns, and by far the cheapest to build, and their operating cost is about on a par with the compartment type. The prevailing type of compartment kiln used in this country has been that of the German Mendheim, and also those of P. L. Youngren. The moving fire type of kiln is becoming out of date, and a moving ware kiln will take about 10–15% less coal than the moving fire type. Also a much larger amount of ware is tied up in the kilns of the moving fire type which is expensive. Of the moving car type the muffle kilns are used for ware having a short burning range, as brick and tile, while direct fired kilns are used for wares having a larger burning range as pottery and refractories. H. G. SCHURECHT

103. Automatic stokers in brickwork. ANON. *Brick Pottery Trades Jour.*, **30**, 80(1922).—Automatic stokers for boilers are invaluable when the boilers are sufficiently large or sufficiently numerous to warrant them. Unfortunately, there is a difference of

opinion among engineers as to the smallest boiler for which it pays to install an automatic stoker, but it is generally agreed that they offer no advantage for plants of less than 150 h.p., and should not usually be installed for plants of less than 500 h.p., so that few brickworks can use them to advantage. In large power installations they are invaluable, and save at least 10% of fuel. Those brick works which profit by the use of automatic stokers do so because they enable a very poor quality of coal slack to be used which could not be employed for hand-fired boilers as the fires would require too much attention. The rate of combustion should be adjusted so that the automatic stoker gives the best results obtainable with the available coal. Sometimes, by increasing or reducing the rate of combustion, the efficiency of the automatic stoker may be greatly improved. For many purposes a rate of 25 lbs. of coal per sq. ft. of grate area is the best rate of combustion with an automatic stoker, but occasionally much higher rates are desirable, according to the coal and the boiler. H. G. SCHURECHT

104. Deposits brick in neat pile on job. ANON. *Brick and Clay Record*, **60**, 538–540 (1922).—A new brick truck with improvements for loading and unloading is described. H. G. SCHURECHT

105. Burning in a coal fired Dutch kiln. ELIAS PETTS. *Brick and Clay Record*, **60**, 533–534(1922).—In firing up draft kilns of the Dutch type P. recommends keeping fires low in beginning, keeping grates well covered and fire should be kept level. Heavy firing causes trouble and fires should be cleaned often. H. G. SCHURECHT

106. Heat conservation studies on kilns. DR. E. REUTLINGER. *Trans. Ger. Ceram. Soc.*, **2**, 33(1921).—Describing the activities of the Society of Heat Conservation Engineers with headquarters in Cologne in providing more scientific control of the burning processes in the ceramic industry. The general procedure is: 1. The study of present methods and expert suggestions for improvements. 2. Introduction of improvements and education of management and personnel to obtain best results. 3. Introduction of practical heat control methods coupled with periodic inspection. 4. Coöperation in research work covering fundamental improvements in the ceramic industry. Observations so far show the following general fundamental weaknesses: A. Burning period too long. B. Coal consumption too high. C. Quality of ware irregular. In the past too much dependence placed on the intelligence and watchfulness of the burners. F. A. W.

107. Absorption of hollow tile. ANON. *Technical News Bulletin of U. S. Bureau of Standards*, **60**, 12.—An investigation has been conducted by the Bureau of Standards to determine the difference in results obtained with various methods and their effectiveness in determining the total porosity. Specimens of the different types of clay were successively immersed in water for periods up to 9 days and in boiling water for periods up to 5 hours with detern. of rates of absorption. Similar deterns. were made under vacuum and finally the total porosity was obtained by volume and sp. gr. measurements. The results, while varying considerably between different types of clay, are in general: (1) Absorption detd. by cold water immersion does not approach near enough to complete saturation to give practical and consistent results; (2) the best practical method consists in boiling for 5 hours, cooling the water and specimens to room temperature, and allowing them to soak for 1 hour. When about 88% saturation is reached, the absorption thus deterd. is on the average 1.28 times that deterd. by immersion in cold water for 72 hours. (3) Proper treatment under vacuum will give nearly the full saturation and porosity, but the method is probably too complicated for use in acceptance tests. H. F. S.

108. Rational analysis as a plant control. DR. R. RIEKE. *Ber. der Deut. Keram. Gesellschaft.*, **3**, Pt. 1, 24(1922).—The writer reviews several methods of detg. kaolin in clay and advocates the Kallauner-Matejka procedure which permits the detern. of kaolin content in clay with good accuracy in 6–7 hrs. time. R. F. G.

109. Connection between viscosity and chemical constitution of gases. HARRY SCHMIDT. *Z. Elektrochem.*, **28,** 50–5(1922).—A mathematical paper. Proof is put forward that the mean cross-section of the mol. sphere of action in gaseous compds. (which dets. the magnitude of the coeff. of viscosity) conforms to those regularities which are derived geometrically from chem. constitution for the mean cross-section of the mol. itself. H. JERMAIN CREIGHTON (*C. A.*)

110. The manufacture of ceramite. A. E. BUCH. *Kalk, Gips u. Schamotte Ztg.*, **28,** No. 13 (July 7, 1921); *Chimie et industrie*, **7,** 101(1922).—Ceramite is an artificial product, prepd. from powdered clay and quartz sand. The mixt. is fired at cone No. 13. A stone of Hungarian origin showed: SiO_2 54, Al_2O_3 14, Fe_2O_3 8, CaO 16, and MgO 4–5. A. P.-C. (*C. A.*)

PATENTS

111. Means for making building blocks. HARRY E. CLOUSER and EDGAR R. THORNTON. U. S. 1,410,166, March 21, 1922. An app. for making building blocks comprising a support, a mold container fixed thereto, mold-pieces removably fitted in the container, the container being open ended, and arranged to receive the block material from above, means for pressing the material into the vol. included by the mold-pieces, and means for then freeing the mold from the block by a movement of the former in a horizontal plane. C. M. S., JR.

112. Processes for the manufacture of briquettes. E. POLLACSEK. E. P. 157,908, October, 1921. Briquettes are prepared by compressing in the cold state a mixture of coal dust, or rubbish or waste metals, and a binder prepared from alkaline sulphite-cellulose waste lye and mineral oil as described in E. P. 157,907.
H. Hg. (*Jour. Chem. Ind.*)

113. Apparatus for the manufacture of hollow bricks closed on all sides. AUGUST KAHR. Germany 1,411,170, March 28, 1922. In a continuous hollow brick or tile making machine, the combination with a mouth-piece through which clay is expressed: of a cylindrical rotatable core having a clay forwarding recess in its periphery and having means to conduct air to the interior of the clay string during the rotation of the core.
C. M. S., JR.

114. Twin wall brick. THOMAS W. PEIRCE. U. S. 1,410,953, March 28, 1922. A reversible channel brick of the kind described, of a width to extend from face to face of a wall, comprising two wall portions each cored longitudinally and united intermediate their height by a central web defining, with the inner faces of the wall portions, a plurality of centrally located air channels. C. M. S., JR.

115. Glass. E. C. SULLIVAN AND W. C. TAYLOR. U. S. 1,408,145, Feb. 28, 1922. A glass adapted for *making elec. lamp bulbs* is formed from SiO_2 71.9–74.5, Na_2O 20.2–21.1, Al_2O_3 0–2, CaO 2.45–2.77 and MgO 1.95–2.6%. Cf. *Ceram. Abs.*, **1,** 82(1922). (*C. A.*)

Glass

116. The stability relationships of the oxides of silicon and fused silica. RUDOLF WIETZEL. *Z. Anorg. Chem.*, **116,** 71(1921).—A 24 page article which is summed up by the author as follows: The following data were detd. exp. (1) The heat of cryst. at room temp. of cristobalite, quartz and chalcedony, measured as the difference of the heats of soln. in HF of the fused silica and the crystd. form. (2) The mean sp. hts. up to the m.p. (3) The m.p. of cristobalite as 1696°. The m.p. of quartz was *estimated* at 1600–1670°. In the case of cristobalite and quartz variations in the inversion point and in the heat of inversion were established. These were explained as due to grains of different size. It appeared that chalcedony exhibited no *unusual* SiO_2 modification

but was quartz of microcrystallin structure. The following systems were investigated in the light of Nernst's ht. theorem.

Fused Silica – Cristobalite
Fused Silica – Quartz
Cristobalite – Quartz

The calcd. A-U diag. for cristobalite-quartz is in complete harmony with the observations. Also the facts that fine grained and twinned substances possess a lower inversion point are consequent of the theory. In the systems with a "glass" phase the establishment of a diag. is attended with difficulties, which is explained by the fact that fused silica and apparently all amorphous-glassy subst. even at the lowest experimental temp. depart considerably from the Deby's T^3 low. The theory therefore indicates the reverse of the conjecture that the sp. ht. decreases to the zero point.

E. WARD TILLOTSON

117. The annealing of glass. TAFFIN. *Compt. rend.*, **174,** 36–9(1922).—Adams and Williamson (*Ceram. Abs.*, **1,** 166(1922)) obtained a law for the release of stress in glass. T. from a number of expts. concludes that while this law represents the results accurately enough over certain limits of stress, a more complicated equation is needed for a more extended range. Two forms for such equations are suggested.

E. D. W. (*C. A.*)

PATENTS

118. Glass-working mechanism. NOBLE W. HARTMAN. U. S. 1,408,000, Feb. 28, 1922. A glass-blowing machine comprising a stationary frame, a non-traveling mold mounted thereon, a blow-pipe, means for rotating the blow-pipe about its longitudinal axis and for swinging it from the mold into a glass pot to gather a charge of glass and then back to the mold, means for marvering the charge during its return to the mold, means for admitting air to the blow-pipe while in operative position with respect to the mold and means for removing the blown article from the blow-pipe during its movement toward the glass pot, the aforesaid means comprising means for causing the aforestated operns. to be automatic and to follow a predetermined sequence, and a single means for supporting the blow-pipe and maintaining it in substantially the same vertical plane during all of the opern.

C. M. S., JR.

119. Glass. EUGENE C. SULLIVAN AND WILLIAM CHITTENDEN TAYLOR. U. S. 1,408,145, Feb. 28, 1922. Cf. *Ceram. Abs.*, **1,** 82(1922). A glass contg. over 70% silica, over 20% soda and oxides of bivalent elements of the second group of the periodic system, the mol. percentage of the oxides of bivalent elements totaling 7 and less than 12 and also contg. over 1% of alumina.

C. M. S., JR.

120. Initial-puff mechanism for glass-blowing machines. JACOB WEISENBERGER. U. S. 1,410,857, March 28, 1922. In a device of this kind, the combination of a blow-pipe frame, a cam movable in respect to the frame, a fixed cam plate, a spring actuated air pump for injecting an air puff into a gather of glass carried on the end of a blow-pipe in the frame, means actuated by the movement of the frame for cocking the pump, a trigger mechanism for releasing the pump, a rock-shaft mounted on the cam plate and having a laterally extending arm in engagement with the trigger releasing mechanism, and means for actuating the rock-shaft by the movement of the cam in respect to the blow-pipe frame.

C. M. S., JR.

121. Glass. WILLIAM CHITTENDEN TAYLOR. U. S. 1,411,133, March 28, 1922. A glass opaque to the visible light in plates 6 mm. in thickness, and containing manganese dioxide and chromium sesqui-oxide.

C. M. S., JR.

122. Glass. WILLIAM CHITTENDEN TAYLOR. U. S. 1,411,134, March 28, 1922. The process of intensifying the color action due to manganese-dioxide by adding to the glass an oxygen compd. of chromium.

C. M. S., JR.

123. Glass-treating fabric and emulsion. ALBERT L. CLAPP. U. S. 1,411,409, April 4, 1922. A wiper for glass comprising a sheet of fibrous material impregnated with an emulsion of kerosene, glycerine and soap. C. M. S., JR.

124. Glass cutter. JOHN R. SCOHY. U. S. 1,411,524, April 4, 1922. In a glass cutter for severing glass cylinders a frame, the edges of the frame having a curvature substantially the same as that of the glass cylinder to be cut, a glass cutter pivotally mounted on the frame and having cutting point, means for producing a substantially constant pressure of the glass cutting point, and means for maintaining a constant direction of pressure relative to the portion of the surface of the glass cylinder against which the point is pressed. C. M. S., JR.

125. Metallizing pottery and glass. Q. MARINO. Brit. 172,723, Sept. 11, 1920. The glaze is removed or the surface roughened by chem. or mechanical means, a silver coating is formed by a chem. process and finally plated with a metal or alloy by electrolysis. The silvering process consists in applying a soln. of $AgNO_3$ in alc., or alc. and ether, allowing the solvent to evap., applying a soln. of formic acid or of formate of Na, K, or NH_4, brushing the surface with a fine wire brush, dipping the article in warm soln. (*C. A.*)

126. Glass manufacture; crucibles, etc. NAAMLOOZE VENNOOTSCHAP. PHILIPS' GLOEILAMPENFABRIEKEN. Brit. 172,610, Nov. 9, 1921. App. for handling or working molten glass is made of a metal or alloy having a high m. p., not evolving gas when heated and forming an adherent and insol. coating of oxide which protects it from attack by the molten glass. Alloys of Cr or Al with Fe, Co, and Ni are mentioned. An alloy of 60% Fe with 40% Cr in particular is suggested. (*C. A.*)

Cement, Lime and Plaster

127. The variation with the temperature of the thermal conductivity of cast iron. E. E. HALL. *Phys. Rev.*, **19**, 237–40(1922).—Results on Fe contg. 3.5% C 2.2% Si and 0.64% Mn indicate that the cond. at 542° is between 2 and 3 times its value at 195°. E. J. C. (*C. A.*)

128. Homogeneity and the raw materials of cements. JULES DAUTREBANDE. *Rev. Mat. Constr. Trav. Pub.*, **149**, 25–27(1922).—Foreign materials are added to cements (a) At the time of grinding the cement: (1) *Materials having a chem. action on the cement.* Such substances as $CaSO_4$ and $CaCl_2$ are added with the object of regulating the setting of the cement. These materials form sulfo-aluminates and chloro-aluminates of lime respectively. (2) *Materials having only a physical action on cement.* These are inert materials as blast fur. slags put in to modify the qualities of the cement. The result is to slow up the setting, to diminish somewhat the tensile strength and to diminish the sp. gr. of the cement. (b) At the time of mixing the cement for use. (1) Sodium carbonate accelerates the setting. (2) Materials to make the mortar of the cement impermeable—such as finely divided calcined clay or slaked lime. Methods for detecting foreign materials in cements. (1) *Boiling water test.* The presence of slag is shown by the blue-green color developed on a test piece when held in boiling water, due to iron sulphide in the slag. Sulfur in cement is usually there as the sulfate, which does not give a coloration. (2) *Microscopic examn.* Slag particles may easily be distinguished by their blue tinge. (3) *Flotation in methylene iodide mixture.* A mixture of benzene and methylene iodide having a density of 2.93 is prepared—the cement having a density of about 3.1 settles, while foreign subs. as sand, siliceous materials, limestones, chalk and slag will float. (4) *Chemical analysis.* A sample of cement is screened by a 200 mesh screen, and the finer material is further separated by elutriation. The chem. analyses of the finest and coarsest divisions will show greater differences in compn. than would result from screenings of a sample of pure cement. LOUIS NAVIAS

129. Lighting up a modern vertical cement kiln. C. TSOUNTAS. *Rev. Mat. Constr. Trav. Pub.*, **151,** 70–1(1922).—After an inspection of the mech. parts, to make sure that they are functioning properly, a new kiln is filled in with wood on the grate 1 m. high, and then burned so as to dry out the masonry thoroughly. Large clinkers (about 12–13 cms. in diam.) or waste brick are then fed in thru the mouth of the kiln on to the grate, by means of a wicker basket suspended by its handles by two ropes. Much damage can be done to the refractory lining, if clinkers are just dropped in. The kiln is filled up to within 3 m. below the mouth of the kiln. The clinkers are then levelled off and green brick are lined up in layers against the refractory lining on their narrow and longer sides, one deep. On the clinkers, straw and oiled cotton-waste to a depth of about 50 cms. are filled, then kindling wood for a depth of about 70 cms. Four wooden conduits, 20 cms. × 20 cms. × 3 meters long, are then stuck into the kindling wood in a vertical position. Around the conduits a layer of coke is put, making it thicker at the periphery than at the center. On the coke, a section of green brick is laid in criss-cross manner, so as to leave plenty of air space for combustion. Alternate sections of coke and green brick are laid down until the kiln is full, not forgetting the continuous green brick lining that is being simultaneously set up against the kiln lining proper. The wts. of successive beds of coke decrease, (240–220–200 to 100 kgs.), as the number of brick in a section increase (80–100–120 to 200). Kerosene is then poured down the conduits, and each one fired at the bottom with a lighted fagot. The tops of the conduits are then covered with brick, and the fuel allowed to burn slowly. As the wood burns the material packs and the kiln is continuously kept full by supplying the green brick lining and filler. In the course of 18–20 hrs. the flame will have mounted to the mouth whereupon the grate is gotten ready to draw the kiln, which is then ready for regular service.

LOUIS NAVIAS

130. Aging of ground clinker. LE GUEN. *Rev. Mat. Constr. Trav. Pub.*, **151,** 76(1922).—Clinker sept. from lime by bolting, is ground in ball mills to 60 mesh, then stored for aging. The grinding cuts down the aging period to about $^1/_5$ the time usually necessary for the unground clinker. A more homogeneous product is also insured.

LOUIS NAVIAS

131. Hydraulic lime plant at Montebourg, (Manche) France. ANON. *Rev. Mat. Constr. Trav. Pub.*, **150,** 55–57(1922).—General description of plant and product, with schematic plan of operns.

LOUIS NAVIAS

132. Artificial Portland cement plant at Montebourg (Manche), France. ANON. *Rev. Mat. Constr. Trav. Pub.*, **148,** 4–5, **149,** 27–30, **150,** 51–55(1922).—Description of the lime and clay quarries, prepn. of materials, grinding, burning, storing, labs., properties and uses of their cement, together with plans and photographs of the plant.

LOUIS NAVIAS

133. The theory and practice of stone-wood (magnesia cement or "composition") floorings. A. STETTBACHER. *Schweiz. Chem. Ztg.*, **1921,** 113–7.—The use of this material is increasing but there are occasional failures through improper technic in prepn. or application or exposure. For the properties of magnesia cements see "Magnesia Cement Plastics" *Schweiz Chem. Ztg.*, **1919,** 198–201 and "Composition Flooring" by H. M. Hooker, *Eng. Soc. Western Penn.*, **29,** 305–338, 418–44(1913).—MgO, $MgCl_2$ consists of MgO 0.423, and $MgCl_2$ 1 pt. In practice, however, the standard formula of the associated German mfrs. is 2.40–2.70 pts. of MgO by wt. for 1 pt. $MgCl_2$. Fillers are also used. If the MgO is less than 2.40 the hygroscopic properties of $MgCl_2$ interfere. Ordinary compn. flooring contains (excluding mineral and color addns.) 6 pts. by wt. of burnt magnesite, 5 of cryst. $MgCl_2$ (2.30 anhydr.), and 2 of wood meal. A table is given of corrections if magnesite of less than 100% is used. $MgCl_2$ solns. with sp. gr. from 1.152 to 1.242, contg. 42 to 64% of cryst. $MgCl_2$ are used. A table shows sp.

gr. and anhyd. $MgCl_2$ content. $MgCl_2.6H_2O$ contains 46.9% $MgCl_2$. Enough $MgCl_2$ soln. is used to make a stiff paste. Arbitrary grades, *e. g.*, 15 and 18 are used for solns. of 1.152 and 1.184, resp. The corresponding vol. in l. per 5 kg. of cryst. $MgCl_2$ is stated. Analyses of compn. flooring always show some free $MgCl_2$ but a little does no harm. Two analyses show: moisture 4.46–4.01%, wood meal (ash and water-free) 11.50–15.52%, silicates 4.68–4.80%, Fe_2O_3 and Al_2O_3 2.02–2.41%, $CaSO_4$ 1.95–1.66%, $MgCO_3$ 13.02–11.84%, MgO (present as hydroxide and oxychloride) 20.40–17.35%, $MgCl_2$ (H_2O-free) 10.21–10.88% (combined 7.18–7.29%), combined water and org. matter 20.17–19.98%. The ratios of $MgCl_2$ (total) to MgO in all forms in these two cases are 1:3 and 1:25 as compared with the standard ratios of 1:2.4 to 2.7. Some of the MgO changes to useless $MgCO_3$ on standing and some of the $MgCl_2$ remains uncombined. It is doubtful whether the method of detg. this is accurate. It is evident that close techical supervision of compn. flooring is vital. Grecian magnesite is used.

JAS. O. HANDY (*C. A.*)

134. Iron blast furnace slags and their use as building material. RICHARD GRÜN. *Z. angew. Chem.*, **34,** Aufsatzteil, 101–2(1921).—These slags consist of CaO, SiO_2 and Al_2O_3 with small amts. of MnO, MgO and FeO. If unusually high in CaO they are less viscous. The usual uses for granulated and lump slag are mentioned and coal mine filling is suggested. Slag sand mixed with $Ca(OH_2)$ makes a good mortar. Slag with soda and sand adns. should make good glass. Cement manuf. is the rational use for slag. Its normal av. compn. requires only slight modification by CaO addn. This cannot be readily done because of the large heat requirement. G. has used with success an elec. furnace for making CaO addns. Passow has proved that for cement making, slags must have the phys. structure produced by rapid cooling. Otherwise they will not set even if of correct chem. compn. It is necessary also to have as accelerator for the finely ground slag a quantity of portland cement clinker equal to at least $^1/_6$ of the slag. Iron portland cement contains approx. 2 parts portland cement to 1 part slag. Slag lime bricks are made as sand lime bricks are made. They are best hardened by exposure to the exhaust from gas-engines. A porous brick is made by pressing and steaming a mixt. of lime and fine slag with granulated slag.

J. O. H. (*C. A.*)

135. Report on heat insulators. ANON. H. M. Stationery Office, Kingsway, London, W. C., *Special Rept.*, No. 5(1922); *Analyst*, **47,** 119–22.—An abstract. Special app. was devised for the measurement of thermal cond. in abs. measure. Data obtained indicate practically the same thermal cond. for cork, slag wool, charcoal and wood fibers, when of good quality and dry (0.00011 g. cal. per sec. per cm. per l.). Different brands of cork, etc., of good quality show but little differences in their efficiencies as insulators. Tests indicate that a considerable decrease in the insulating efficiency may take place in use. Heat transmission is complicated in the case of coarse granular materials by the circulation of convection currents. Rubber expanded by gas into a highly cellular state has a cond. of 0.000085 which is lower than that of cork and only $1^1/_2$ times that of still air. The original describes the method and app. used for detg. the sp. heats of the materials.

W. H. BOYNTON (*C. A.*)

136. Crystallization and transposition phenomena in the hardening of cement. DR. SCHOTT. *Zement*, **10,** 294–5, 306–8, 328–32(1921); *Chimie & industrie*, **7,** 322; cf. *Ceram. Abs.*, **1,** 91(1922).—On examg. the fracture of cement, crystals are apparent with a magnifying glass, or even with the naked eye when the light strikes properly; but they are too small to be sepd. and analyzed. S. used the following method for obtaining larger crystals: Pour a cement mortar of ordinary consistency on a glass plate covered with a moist sheet of blotting paper and press with a similar glass plate placed on top of the cement. When the cement has set, remove the glass plates and blotting paper, cut in-

to disks, perforate and lay on a wire screen free from rust and provided with a wooden rim, place in a cylindrical glass jar of such dimensions that a space of 1–2 mm. is left between the edge of the disks and the glass, fill the jar with water, and stopper. After a considerable length of time the disks coalesce. First of all colloidal matter, consisting of Ca $(OH)_2$, seps. from the mass, followed after some time by an intense production of very thin foliated crystals of each disk. In 6 yrs. crystals of 0.5 cm. face were obtained. They were hexagonal, negative, and uniaxial; their chem. compn. was H_2O 21.95, SiO_2 2.10, Al_2O_3 0.85, CaO 75.45%, corresponding to $CaO.H_2O$ (CaO 75.67, H_2O 24.33). This confirms the hypothesis that the setting of cement is due to the crystn. of $Ca(OH)_2$. The limit of the CaO content is that which makes the cement expand. S. then investigated the effect of burning, of clinkering temp., and of the various materials contained in the cement. A. P.-C. (*C. A.*)

137. Advantages of hydrated lime in paving concrete. T. B. SHERTZER. *Can. Eng.*, **42,** 111–112(1922).—The advantages claimed are the prevention of segregation and consequent increase in uniformity; lubrication of the concrete which makes placing and finishing easier; formation of an insol. water-tight skin on the surface; promotion of a more compact arrangement of the other ingredients and efficiency as a water-tightener. J. C. WITT (*C. A.*)

PATENTS

138. Cementing or luting composition. K. O. DUFVA. U. S. 1,407,194, Feb. 21, 1922. A cementing compn. adapted for use on steam pipe joints is formed of powdered corundum and paint, rosin and shellac varnish. (*C. A.*)

139. Separating composition for plaster casts. J. B. JONES. U. S. 1,406,651, Feb. 14, 1922. Shellac dissolved in an aq. soln. of borax. (*C. A.*)

140. Plastic composition and process of making the same. GEORGE M. FORMBY. U. S. 1,409,939, March 21, 1922. The herein described new article of manuf. containing a calcium oxychloride that has been heated with lime in the presence of water, and the compd. thus produced mixed with plaster of Paris. C. M. S., JR.

141. Plastic cement mixture. W. E. W. RICHARDS. U. S. 1,408,401, Feb. 28, 1922. A mixt. of powd. clay, ground cement and fiber with H_2O is molded under pressure to form *elec. insulators or other articles.* (*C. A.*)

142. Dental cement. S. SCHIFF. (*Jour. Amer. Ceram. Soc.*, **4,** 1013(1921)). U. S. 1,408,960, Mar. 7, 1922. An emulsoid acetogel of silicic acid is added to amixt. formed of pulverulent Al K silicate and H_3PO_4. (*C. A.*)

BULLETIN
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A Monthly Publication Devoted to Proceedings
of the Society, Discussions of Plant Problems, Discussions
of Technical and Scientific Questions and
Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 1 August, 1922 No. 4

EDITORIALS

CONVENTIONS

The American Ceramic Society is planning for three conventions to be held in the immediate future: (1) Summer Excursion Meeting the week of August 13; (2) Ceramic Day at National Exposition of Chemical Industries the week of September 11, and (3) the Annual Meeting, in this instance the twenty-fifth anniversary, the week of February 12, 1923. Do these "get togethers" pay dividends commensurate with the invested time and money of those who attend?

Many hundred conventions are held each year. All sorts of mercantile, manufacturing, agricultural, professional, educational, scientific, political, social and fraternal groups meet at least once a year and some of them more often. Committees of all sorts hold frequent meetings, the members often traveling long distances at large expenditures of time and money. Are the benefits derived from attendance at conventions and committee meetings commensurate with the costs to the individuals and to the concerns which these individuals represent?

Rather than evaluating these benefits it is sufficient for the purpose at hand to consider only the circumstantial evidence to prove that attendance at conventions must repay more than the monetary equivalent of time and money expended, or the attendance at conventions would not be constantly increasing, and there would not be such a remarkable in-

crease in the number of conventions each succeeding year. Convention bureaus, reporting agencies and convention journals find an increased demand for the peculiar service which each renders. Conventions have been recognized as business, political, educational and social necessities. An increasing investment in conventions by the leaders in every walk of life bespeaks the solid values enjoyed by those who attend.

Summer Excursion.—The Summer Excursion Meeting of this Society which is routed from Rochester, N. Y., to Montreal, Buckingham, Ottawa, Verona, Kingston, Toronto and Hamilton will have a peculiar value for those who attend in (1) broadened and intensified acquaintance with fellow ceramists; (2) mutual exchange of experience and information on manufacturing problems; (3) increased knowledge through inspection of manufacturing plants and feldspar quarries; (4) cultural advantages of travel to cities of individual and universal interest; (5) cultural benefits of acquaintance with persons who have accomplished important work; and (6) an invigorating outing on lake and river, through some of nature's most beautiful and most thrilling scenes, and to places that range from the most sophisticated cities to the backwoods camp. Such a wide variety of benefits is seldom obtainable from conventions as is offered by this Summer Excursion Meeting.

Chemical Exposition.—The convention in New York City in connection with the National Exposition of Chemical Industries is well established as an occasion of profit to those who attend. It is sufficient in this writing to say that our program committee under the leadership of Mr. R. D. Landrum and the secretaries of the several Industrial Divisions of the Society is planning a day of interest and value. The Exposition is a broad educational institution well worth the time and expense of a thorough study by ceramists.

As for our **Silver Jubilee Convention** next February in Pittsburgh, it will be the biggest meeting in the interest of coöperative Ceramic Research yet held. The Divisions and Committees are making plans for a potent occasion for advancing the ceramic arts and sciences. The Charter members are planning to renew the spirit of a quarter century past which prompted them in the face of industrial opposition to begin this mutual exchange of knowledge and coöperation in investigation of unsolved problems. The younger members are planning to show the results of present day broad-minded and hearty participation in cooperative research.

Ceramic workers can ill afford to neglect the advantages offered by these well planned conventions. It is expected that a goodly number will attend each of the three meetings now scheduled.

SERVICE AND COST

A Chat with The Secretary

Increased Service at Less Cost.—The recent numbers of the Journal have been remarkable in several respects. The increase in number of original papers and discussions, and of abstracts of the world's literature is self-evident to the casual observer but few we find who have observed the greater length and width of the printed column on each page, by means of which the amount of reading matter per page is increased more than 26 per cent. If the printed matter in the April number had been in this wider and longer column it would have needed only 66 rather than 88 pages.

Savings Are Re-invested in More Service Rendered.—We wish to stress the point that this 26 per cent greater capacity column gives a net saving per material printed, which saving is re-invested in more printing. It is this sort of economy in the interest of the subscribers that the Committee on Publications is studying so as to give even greater returns for membership subscriptions.

Scientific management and cost systems have been worked out for printers with resultant fixed scale of charges which makes the working tools of the Society cost much more now than they did before the war. This in turn calls for closer managing on the part of the executives of the Society, and, even with close managing, expenses cannot be met without the assistance of the members.

Expenses Have Increased but Membership Dues Have Been Kept Low.—The officers of the Society are constantly striving to give more and more service without increasing the annual subscription, but even with the most thrifty shopping for the working tools, the officers are at all times confronted with the fact that there are only seven hundred and fifty cents in each personal subscription. This Society is unique because the low personal membership dues have been maintained in spite of the increased cost of everything.

Journal Published at a Loss.—In the year 1921 the Journal, though small, was published at a loss of over $5,000. The exact figures are given in the Year Book. This year the executives of the Society courageously trusted to the coöperation of every member and to the farsightedness of corporations, in their decision to issue an even larger and more costly Journal, on the grounds that such was absolutely necessary if the Society was to assume its just obligations in these days of more earnest seeking for technical and scientific information. They assumed that persons interested in ceramics and in their own welfare would secure additional subscribers to the support of the greater service thus rendered. These expectations have been realized to some extent and it

is confidently expected that the full quota of required new members will be secured just as soon as the members realize the larger advantage that accrues to each individual and to each corporation from a more virile and productive organization.

Importance of Greater Membership Support.—Self-evident should be the greater things which could be accomplished when the membership is brought to the full strength required for this Society to meet its obligations in the more aggressive coöperative research program on which the ceramic industrial groups are now engaged. The Trade Associations, the Trade Journals, the Federal Bureaus, the Universities and the manufacturing concerns need this central organization devoted solely to technical and scientific research. They are coöperating agencies each engaged on its special problems but each dependent upon the American Ceramic Society, as upon each other, to have sufficient strength and be sufficiently productive to work into a unit structure the results obtained by them and by individuals so that each may have the benefit of information obtained by the others on the many things that are of common concern.

The executives will continue to plan ways and means of obtaining the most for those who join in support of this Society, but the most urgent thing right now is the presentation to many others that it is not only their duty but their opportunity to share in the support of this work.

If you are of the belief that your membership support is a good investment for you, why not increase the value of your membership by inviting others to share in the returns. This is the only way you can receive greater service at the same cost.

EDWIN WARD TILLOTSON, JR.

Edwin Ward Tillotson, Jr., a recognized authority on the chemistry and technology of glass, and Assistant Director of the Mellon Institute of Industrial Research of the University of Pittsburgh, was born at Farmington, Conn., on February 28, 1884. He received his professional chemical education at Yale University and was graduated in 1906 with the degree of B.A.; in 1909 he received the degree of Ph.D.

Following the completion of his graduate work at Yale, Dr. Tillotson joined the Department of Industrial Research of the University of Kansas, where he remained for four years as an Industrial Fellow. In 1913, he came to the Mellon Institute of Industrial Research as Assistant Director. The scientific investigations carried out by Dr. Tillotson at the University of Kansas related to a study of the relation between the optical properties of glass and its chemical composition. The scientifically important results

of this research were published in a series of six papers in *The Journal of Industrial and Engineering Chemistry* (1911–12). His recent publications include:

Etch figures, *J. Ind. Eng. Chem.*, **9,** 937 (1917).

Molecular Compounds, *J. Amer. Ceram. Soc.*, **1,** 76 (1918).

The New Factory of the Monongah Glass Co., *J. Amer. Ceram. Soc.*, **4,** 3–24 (1921).

Putting the Glass Industry on a Scientific Basis, *Chem. & Met. Eng.*, **23,** 461 (1920).

Waste in the Glass Industry, *Chem. & Met. Eng.*, **25,** 437 (1921).

The Manufacture of Constructional Glass in the United States, *J. Soc. Chem. Ind.*, **40,** 155 (1921).

Dr. Tillotson is now in supervisory charge of all the Mellon Institute investigations in the field of ceramics, in addition to other research work of the Institute.

Dr. E. W. Tillotson, Vice-President American Ceramic Society, Asst. Director, Mellon Institute of Industrial Research, Pittsburgh, Pa.

Dr. Tillotson is an active member of the American Chemical Society and of the American Ceramic Society. He is a past chairman (1920) of the Pittsburgh Section of the American Chemical Society and at present is a member of the Council of the Society.

In the affairs of the American Ceramic Society he has held the following appointments:

Committee on Publications, 1919–.

Secretary of the Glass Division, 1919–1922.

Vice-President, 1922.

Amer. Ceram. Soc. representative on A.S.T.M. Committee D-10, 1922.

ACTION OF REFRACTORIES UNDER LOAD CONDITIONS AT HIGH TEMPERATURES

The "load test" is now used in all countries and is considered one of the most important in the testing of refractories. Very few there are who know when and by whom it was devised and first used, hence this note of acknowledgment.

The action of refractories under load conditions at high temperatures was first studied by Lemon Parker and reported by him in a paper before this Society in 1905. This test was developed and refined by Professor A. V. Bleininger in subsequent years but the credit for the basic conception

belongs to Mr. Parker. We are pleased that we can make this acknowledgment of credit as belonging to one of our fellow members while he is yet active in the affairs of the Society.

Mr. Parker has been engaged in the manufacture of fire-clay refractories since 1886, serving in various capacities in the Parker-Russell Mining and Manufacturing Company. He was made President and General Manager in 1915.

It was in 1902 that this company was forced to use a high alumina clay in substitution for the silicious clays which they had been using in bench tiles. The situation demanded the adoption of tests that would involve the critical service factors, and which could be quickly executed with reliable results. This caused Mr. Parker to invent the load test.

SURVEY OF SIMPLIFICATION NEEDS TO BE CONDUCTED BY AMERICAN ENGINEERING STANDARDS COMMITTEE

At the request of Secretary Herbert Hoover, of the Department of Commerce, the American Engineering Standards Committee will undertake at once a canvass to determine what simplification in manufactured products is most needed and most desirable. This canvass will be conducted through the engineering and technical bodies having representatives on the Committee or coöperating in its work. The survey of simplification or standardization needs and possibilities will extend into almost every industry in America.

This assignment to the American Engineering Standards Committee is one of Secretary Hoover's steps to retrieve for American Industry a few of the many billions of dollars wasted annually, as revealed in the report on waste in industry which was made not long ago by a committee also appointed by Mr. Hoover while he was chairman of the Federated American Engineering Societies. The latter committee found that waste in industry was due largely to an overmultiplicity in number of products as well as to inefficiency in process.

Of equal significance is the fact that Mr. Hoover's request that the American Engineering Standards Committee conduct this survey and the acceptance of the assignment by the Committee indicate a coördination of the work in the simplification of manufactured products, sponsored by Secretary Hoover, and the work of the American Engineering Standards Committee in the unification of standards on a national basis.

What should be the relationship between the simplification work of the Department of Commerce and the standardization work of the American Engineering Standards Committee has been the subject of considerable discussion. It is clear now that there will be no duplication or overlapping. There seems to be general recognition of the fact that simplification of

product and improvement of process are to a large degree only other words for standardization: that they are standardization put to work. The joint movement for standardization and simplification may, therefore, be said to have begun its work in its own household by standardizing, simplifying, and unifying its own machinery and processes.

The Executive Committee of the A.E.S.C. has, by resolution, pledged the coöperation of the Committee to the Department of Commerce. Representatives of the Committee recently held a conference on the subject with Mr. Hoover at Washington. Subsequently an arrangement was made for permanent exchange of representatives between the two organizations so that there may be the closest possible coöperation between the Commerce Department's Division of Simplified Practice and the American Engineering Standards Committee.

THE EVOLUTION AND DEVELOPMENT OF GLASS HOUSE EQUIPMENT

By J. S. Herzog

ABSTRACT

This paper is an account of the evolution of machinery used in glass-making in which the modern methods are contrasted with the old. *Gas producers, gas burners* and *oil burners* are discussed. In burning gas a greater efficiency obtains when the air entirely surrounds the gas stream as it enters the fire box. In burning oil the high pressure costs more for installation but is more efficient. The tendency is towards automatic machinery for all glass-making operations. Many machines are well nigh perfect but improvements are being made constantly. Mention is made of the need of a better alloy for metal molds. In the glass industry labor represents on the average 40 per cent of the cost of the product. In this respect the glass industry ranks thirteenth.

While glass-making is one of the oldest of the manufacturing industries, it is also one of the newest from a basis of the development of manufacturing processes. Authorities differ as to the origin of glass, but it is very probable that the Egyptians were the first manufacturers in a commercial way. They made glass by a primitive process between 1600 and 1500 B. C.

Geographically and chronologically in the line of development we might list glass manufacture thus: Egypt, Rome, Venice, Germany, Bohemia, France, England, and the United States.

While the ancients produced a great variety of glasses, some of which we have not been able to duplicate, the greatest development in the handling and forming from a purely commercial view-point has been during our time. Due credit must be given them for the processes used as many of our most modern methods are but improved application of those processes.

Pressing glass by means of metal forms was known to the Egyptians; glass replicas of their coins of the time of Thebes have been found. The exact origin of the blowpipe as used in glass manufacture is unknown. It is sufficient to say that it was first used by the Egyptians the second or third century B. C. The application of these two very old processes form the basic foundation of our present day equipment in the shaping or manufacture of glass articles.

Up to the latter part of the last century these processes and their application were but slightly developed. The medal for progress made in the evolution of glass factory equipment for both hemispheres during the past fifty years, belongs without a question of doubt to this wonderful country of ours. The use of gas for fuel has been the greatest factor in this development.

This paper proposes to cover in general, and in many instances in a detailed way, equipment adapted for the glass factory, for fuel, raw material, melting, shaping, tempering and finishing—that is, grinding, polishing and decorating.

In the old days, when wood was the principle fuel used, glass factories were built in or near forests. The locations of our present factories were primarily determined by the fuel supply. After wood, coal, natural gas—and with the exhaustion of natural gas, coal again—have been the dominant factors in the location of glass factories.

With the depletion of natural gas, gas producers and the use of fuel oil have made it possible for glass plants to continue in their original locations. Gas producer plants are of two principle types, raw and washed gas; the latter is the more complete, although the former is the more common type used for glass-making. There are many types of raw gas producers on the market, essentially similar in their general design, differing principally in the degree that they are automatic.

The success of any installation, as to obtaining results at the point of combustion, depends largely upon the arrangement and operation of the tunnels, pipes, dampers and valves. Beginning with a steel or brick tank fired by wheelbarrow and stirred or stoked with a long iron rod, we find today producer plants alone costing many times the former price of a complete glass plant.

Coal arrives at the plant in hopper bottom cars, dumped into surface receiving hoppers, from there conveyed by bucket or belt to the crusher and by the same means to storage tanks over the producers. From these tanks the producers are charged by gravity automatically through the receiving head of the producer. Some part of the producer rotates around a vertical axis. This causes the necessary operation for the stoking or raking and cleaning of the fire. The ashes are automatically cleaned away from the lower part of the producer and conveyed to the dump or storage. The entire process requires one man who manipulates the levers and pushes the buttons.

Several types of raw gas burners have been developed. These burners provide for the mixing of air with the gas as it enters the fire box. Volume air is blown either through or around the gas discharge. The more efficient seem to be so constructed that the air entirely surrounds the gas as it enters the fire box. These types differ only in the places where the air and gas enter the burner and the method of controlling their flow.

Crude oil for glass manufacture is comparatively a new fuel. At present there are two distinct methods used in the industry. Crude oil must be gasified or atomized for successful combustion. The two methods apply to the atomizing process. The common method and the one having the lesser cost of installation consists in atomizing the oil by compressed air at the burner. The oil burned by this method is conveyed by gravity or low pressure pumps to the burner. Fuel oil that reaches the burner under an extremely high pressure is the other method. The pressure back of the oil at the burner atomizes it. The high pressure method

has a higher installation cost, but so far has proven more efficient and economical.

In both methods, whether the oil is stored under or above ground, due care must be exercised in the installation of the system, particularly in the colder districts, and provision must be made for the warming of the oil by the use of steam pipes, both in the storage tanks and the conveying lines. Heat increases the fluidity of the oil and facilitates its handling.

There are a great number of burners on the market, most of them for the more common method of atomizing by compressed air applied at the burner. They differ in their construction only in the method of receiving and distributing the oil and compressed air, and their manner of control. All burners for this method should be provided with facilities for cleaning.

The old glass manufacturer had but one fuel problem—to get his wood cut and hauled to his plant. It is not an infrequent sight in the depleted natural gas districts, to see glass factories equipped with three burners on the tanks and lehrs, for raw gas, natural gas and fuel oil. Two conditions govern as to which is in use, supply and cost.

The handling of raw material has developed with the other departments of glass manufacture, while the wheelbarrow and the hand-shovel are the only raw material handling equipment available in many glass factories, the larger and more modern are supplied with automatic equipment. As raw material for many factories is received in box cars, the power shovel is used to unload cars into hoppers from which it is conveyed to the storage tanks by belt or bucket conveyors. These tanks are circular in cross section, with capacities for from three weeks to ninety days normal consumption. There is a tank for each kind of raw material, and sub-divided tanks for materials whose consumption is not so great. These tanks are made of steel and cement. The poured cement tanks seem to be more satisfactory owing to their lower cost of upkeep. Passages are provided under these tanks either for batch mixer car or belt conveyor. The modern factory where economy and quality are desired, should have its cullet crusher, batch mixer and separator.

Quoting from an authority on glass manufacture, "All materials should be reduced to a pulverized condition. There should be a thorough admixture of the batch. By reducing all particles to their finest possible condition, while in a raw state, a closer mechanical association is affected and they expose more surface to all reducing influences, effecting an earlier fusion of particles and a closer combination of results. A thorough admixture of materials is necessary so that *in* the chemical association each particle of sand may find its corresponding portion of alkali, oxide, etc."

Installations of equipment for handling raw material vary as to kind of product, arrangement of plant and money available. In designing an ideal installation, let us assume our product is high grade milk bottles in

large quantities, and we are melting our glass in continuous tanks. We have an inbound siding for our raw material. With the given normal production of our glass melting tanks we erect the necessary number of storage tanks of concrete, with conical tops and flat bottoms; and coat the inside of our tanks with a moisture preventative; the size and number of these tanks to hold raw material for thirty days normal production. We will use the portable type of upright conveyor with power car unloader. The tanks will have two or more properly gated openings in the bottom. There should be a tank for cullet with the crusher mounted under the opening. They should be supported high enough to permit the free passage of combination batch car, scales and mixer, and operated either by electricity or gasoline. The thoroughly mixed batch is dumped into a floor hopper and from there conveyed over separator and thence to storage tanks over dog houses. These tanks are to hold twenty-four hours requirements and are discharged by gravity. Where pot furnaces are used, the foregoing installation could be modified by the use of hand-drawn or power-driven steel batch carts.

The modern furnaces and tanks used for melting glass, besides varying in size, differ in the application of the regenerative and recuperative principles. These processes are of sufficient importance to entitle them to a discussion beyond the scope of this paper.

Tank melting is rapidly crowding out pot melting for commercial products. Except for optical purposes, as beautiful crystal glass is made in tanks as was ever made in pots. Tanks are now in use with dividing partitions and two colors are made in the same tank.

In the operation of the regenerative type, there has recently been put on the market a combined gas and air valve that reverses automatically. It is operated by thermostatic control from the checker work.

Shaping and forming of glass articles was accomplished in a very crude way in the early years of the last century. The blower's pipe and the pontil were the principle tools used. These were supplemented by small tools made of wood and metal and later with molds made from apple or maple chunks.

Up to 1899 glass was taken from pots or tanks by blower's pipes, pontils or ladles. Since then many methods have been developed and patented. The success of the suction process was possibly the incentive that brought out the others. There are five important essentials for the success of any automatic gathering or feeding device.

1. The amount of glass supplied must be adjustable within a reasonable range.
2. The gather or gobs of glass must be uniform in size.
3. The glass must reach the mechanical device at a temperature suitable for forming.

4. The feeding must be adjustable and at such a speed as to synchronize with the operation of the device.

5. If the better quality of product is manufactured, the marks made by the cutting off or forming of the gob must be eradicated.

There are several feeders on the market that meet these requirements, and many others in the process of development. The success of the feeders has made it possible to make many machines entirely automatic. Some of these feeders employ refractory material for paddles or plungers that operate in troughs or cylinders of the same substance. The sucking or vacuum method uses an iron mold for the gob receptacle. By the use of a bait, other processes draw the glass in the form of cylinders, sheets, rods or tubes over rolls or through dies. One recently patented process allows the glass to flow out of the front of a tank, dropping between rolls that form it into window glass of any desired thickness.

Iron molds were introduced as an improvement of the old hardwood blocks. Molds made of cast iron are of three classes: iron, blow molds, paste molds and press molds. Iron blow molds are used if the design or figure on the exterior of the glass article does not permit of its rotation around a vertical axis in the process of blowing. Most of the molds of this class are made in two or more parts. The joints of the sections are reproduced on the glass and care is taken in the designing of the decorations, and the making of the mold to hide these joints or marks as far as possible.

Paste molds are so called from the coating of charcoal and adhesive substance used in covering the interior, or working surface, of the mold. Only such shapes are made in these molds as will permit of rotation. They can be made in two or more sections without the reproduction of joint seams, as the rotating of the glass in the mold removes them. Paste molds were developed from the old maple or apple blocks, and like them cooled by dipping in, or spraying with water. Up to the time of our present machines, bottles (without lettering), lamp chimneys, electric light bulbs, balls for light shades, and blown tableware were the more important articles made in these molds. The development of the paste used has made it possible to make a product as free from tool marks as the best mechanics were able to make by the "off-hand" method.

The manufacture of pressed glass required a new class of molds. The forcing of a plunger into a gob of hot glass replaced the stream of air from a blower's pipe. Molds of this class consist of two essential parts, the mold proper, or die, and the plunger. Other parts such as bottom plates and rings are often used to facilitate the operation of the mold. Hollow articles made in this class of molds must always be of such a shape as will permit of the removal or release of the plunger. Because of this the ingenuity and skill of the designer and mechanic has often been taxed in the manufacture of certain articles.

The metal used in the manufacture of molds and other devices for forming glass is a very important factor in their successful operation. Molds were originally made of just cast iron. The analysis of the iron that entered the casting was of little concern to either the foundryman or the glass manufacturer. Progress demanded a better product and much time and expense have been used to develop castings that would meet the requirements of molds. Steel, nickel, chrome, vanadium, victor metal and monel have been used as alloys with standard pig iron, with varying success. To date, the best all around castings for molds are made of pig iron and returns of the proper analysis. While the working conditions severely tax any metal used for molds, there is a great opportunity for development. An ideal mold iron must produce the article as free from marking as that produced by the "off-hand" process, and as rapidly as the machine will charge and remove the glass from it.

Just at this point it might be well to mention a machine recently put on the market for performing most of the labor in making molds. In many instances this machine will reduce costs.

Without doubt the development of the various bottle-making machines has given glass manufacture its greatest impetus during the past thirty years. Up to 1890 there were practically no power-driven machines in use for shaping glass. The first partially automatic machines were designed and used for making thin blown tumblers, chimneys and similar articles.

Prior to this, the only machine used was the hand lever press. While the press has been greatly improved as to details, the process is the same. Today we have fully automatic machines for making lamp chimneys, lantern globes, gas and electric light shades, tumblers, electric light bulbs, cane glass, tubing, window glass and various forms of pressed shapes. A single man, with these machines and their automatic feeders, carrying-in devices and lehrs, is producing what it formerly required from six to forty workers to do. The time allotted for this paper does not permit further details as to their individual operation.

In the early days glass was reheated for forming and fire polished in the openings of the furnace or tank. Glory-holes or large ovens were then introduced and various devices are now on the market for accomplishing similar or better results. There are portable glory-holes, automatic fire polishing machines and automatic finishing machines. A machine has recently been developed that shapes and rolls a thinner edge on a blown tumbler than can be uniformly accomplished by the "off-hand" process.

Carrying-in devices or conveyors are of two principle types, conveying on endless chain flights or pushing by endless chain on a smooth surface. The common method of placing the product in the lehrs is to push the articles off the carrying-in device on to the lehr pans. These devices have

replaced many boys in the glass factory and are made a part of the blowing or pressing machine, the operator of which looks after the entire unit.

The tempering of glass is a very large subject and I will only touch on the high places. The first systematic tempering was done in ovens. These ovens were heated and after the glass was placed on shelves or in pans, the doors were sealed and the temperature gradually reduced through a predetermined period of from twenty-four to seventy-two hours. The doors were opened and the glass removed. This was a sure but slow process. The old-fashioned pan lehr from fifty to seventy feet long and five feet wide was its successor.

Automatic machines brought out the continuous type which, with its modifications as to operation and construction, is at present the last word for the average manufacturer. There is still some difference of opinion as to the construction of pans and the kind of chain to use.

The use of raw gas for fuel has necessitated in most factories, a change from the open fire lehr to the muffle type. Lehr manufacturers vary considerably in their ideas as to the construction of this type of lehr. One design may prove successful in one plant and, if slightly modified to meet another glass manufacturer's conditions, proves a disastrous failure. Length over-all, width, height, size of flues and fire boxes, heat control and method of firing are far from being standardized.

The tempering of his products is a mighty serious problem to the average glass manufacturer. From natural gas at ten cents and less to thirty cents and over for raw gas is a big jump.

Mr. Collins'[1] paper last year demonstrated from tests made that a heat 25 degrees less than the annealing temperature required a lehring three times as long. An ideal lehr should have perfect heat control.

The use of pyrometers and polariscope, or commercial strain detectors, are of great value in the successful operation of any type of lehr.

An initial heat lehr has been developed and has successfully operated for the tempering of tumblers. This lehr is built close to the machine and the glass enters it immediately after the last operation. The lehr is only about four feet wide and twenty-five feet along. Fuel consumption is low as pyrometer readings run 800° F and under.

Considerable improvement has been made in the grinding and decorating of glass ware. From the grinding of tumblers to the polishing of plate glass, new equipment has been introduced.

Grinding mills have been developed that are semi-automatic. Edge grinders, for tumblers and similar hollow ware, that are semi-automatic and real producers, are on the market. Air brushes for color decorating, needle etchers and acid etching machines, are helping the glass manufacturer to keep down his labor costs.

[1] Collins, *Jour. Amer. Ceram. Soc.*, **4**, 335 (1921).

In the large factories you will find conveyors for the distribution of the finished product. Electric and gasoline small trucks, as well as over head monorail systems are performing a good work.

As one manufacturer, whose plant was fitted with automatic equipment, remarked, "Our raw material and fuel enters the north end and our finished product goes out of the south end. If we had a catsup factory on our south side, the bottles could be filled as they went out of the door; and no hand has touched them except for inspection.

Yet with all these improvements, in 1914 glass-making ranked 13th in percentage of labor cost with respect to the value of the product. Government reports for the year 1917 show labor to be 40.6 per cent in the manufacture of glass.

We have just entered upon a period of automatic glass manufacture, and there is a wonderful opportunity for the progressive equipment builder. He will, with the coöperation and assistance of the glass factory man, attain results beyond our present conception.

SIMPSON FOUNDRY & ENGINEERING CO.
NEWARK, O.

KILN MANIPULATION IN RELATION TO SCHOOL AND STUDIO POTTERY[1]

BY FREDERICK H. RHEAD

ABSTRACT

A suggestion for a chart to be used in connection with the firing of studio and school kilns.

The use of the chart makes it possible to record the time element, amount of fuel, and the temperature curve.

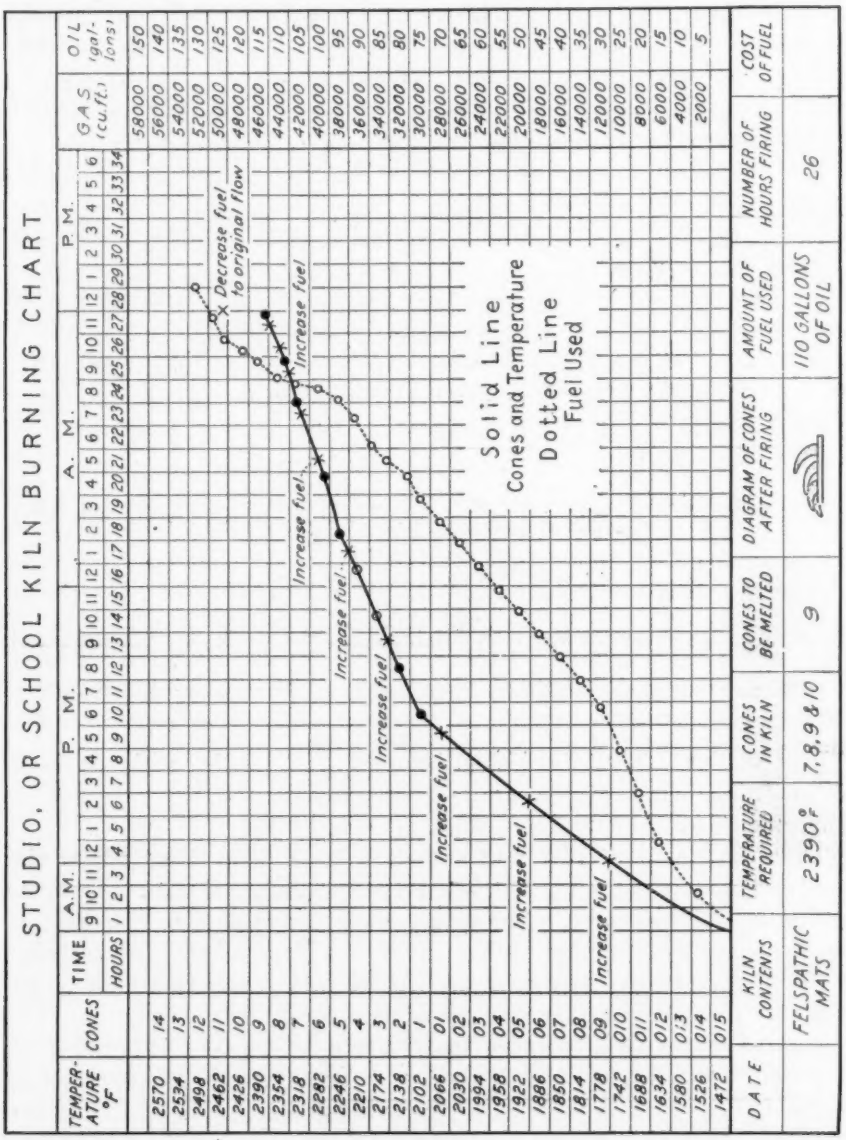
Introduction.—This discussion is concerned chiefly with methods for recording temperatures, the fuel consumption and time element in connection with the burning of studio or school kilns.

There are many studios and schools using pottery kilns where the available funds or appropriations will not permit the installation of mechanical recording equipment, consequently there should be some inexpensive yet practical method of recording every kiln firing. Very few schools or studios use charts to record the various kiln burns, and as a result it is very difficult to standardize the firing process.

Various Types of Recording Instruments.—There are a number of recording instruments. Among these may be mentioned the pyrometers of the Le Chatelier type directly registering and recording the temperatures by means of platinum or base metal thermocouples; the Leeds and Northrup optical pyrometer registering the temperature by comparing the color of the heat of the kiln with the color of the filament of a specially

[1] Art Division, St. Louis Meeting, Feb. 28, 1922.

calibrated electric light bulb; or the prismatic Wedge optical pyrometer. But only the larger schools and studios can afford even the minimum cost of a hundred dollars necessary to purchase and install any of these types.



For the average work with the smaller kilns, the Seger cones are most satisfactory, but it seems obvious that if the kiln firing operations are charted, better control and more uniform results will be obtained.

The Use of the Chart.—The studio worker and the school instructor may acquire the utmost confidence when executing most of the pottery processes, but it always seemed to the writer that most of them balk at the kiln. While kiln firing is an uncertain operation at best, it is the one process that does need the confidence and all the knowledge at the disposal of the operator. The mere lighting of the kiln, the passage of time with the periodic increase of fuel for a particular burn is not enough to insure regular and uniformly repeated results. If each firing can be approximately charted, the operator will possess information which will be found most valuable for future work, and in addition the firing operation can be regulated to a much greater extent than is commonly possible.

The chart outlined gives a fair idea of this method of recording the firing process. It shows the time element, actual time of lighting and finishing the kiln, amount of fuel consumed with the periods of increase, and in the lower part of the chart a diagram of the cones after the kiln is finished.

If air is used, either in connection with oil or gas, a column recording the volume or pressure can be added at the fuel end of the chart. Under such conditions the operation of the kiln, when reducing atmospheres are required, can easily be regulated.

It is a simple matter to rule up a chart for each firing, or blue prints could be made. If I were a manufacturer of portable kilns, I would supply these charts with the kiln.

This system would also be valuable in factories possessing no pyrometer equipment. The number of large plants possessing no filed records of their kiln operations is surprising. No matter how skilful or reliable the kiln fireman may be, it would seem to be good business to have some system where the past and present practice of this most important process may be subject to investigation, supervision and regulation during the burning period.

COLLOQUIUM ON FELDSPAR AND FELDSPAR GRINDING[1]

NOTE BY EDITOR:—In the discussions to date there has been less on quality and specifications than is desired. Eventually there will be a consideration of relative merits of the so-called hard and soft or the more easily fusible and refractory feldspars for general ware, porcelain insulators, floor tile, glazes, etc. Such questions have already received the attention of ceramists, potters and tile manufacturers, whose definite and quite different individual preferences are based on extensive manufacturing experiences. Facts and experiences concerning all of this will be brought out before this colloquium is concluded and before a definite schedule of research is determined. For the present, attention is directed

[1] Continued from *Bull. Amer. Ceram. Soc.*, **1**, 78 (1922).

to methods of milling and effect of each process on cost and quality. A poor grade of feldspar for many requirements is expensive at any price while for several purposes a lower quality of feldspar is as good. The cost, however, should be accordingly lower.

There seems to be a market for each sort of feldspar produced but neither the user nor the producer, generally speaking, seem to have definite knowledge of the requirements for every sort of ceramic ware. It would seem that definite specifications, together with permissible range in variation, would be desired by both parties and it is to this desideratum that this informal colloquium is being directed, taking one step at a time. For the while, attention seems to be directed more on economical methods of milling; but in this there must be a consideration of the quality of feldspar produced, the effect of the grinding process on quality as well as on cost.

Is there a preference for water-ground feldspar and why? Can 160-mesh feldspar be produced as economically and of as good a quality by the dry as by the wet?

What are the considerations, in general, for using wet or dry, conical mills, tube mills or batch mills?

What dimensions of mills are most suitable for given purposes and why?

In a continuous or closed circuit, with wet or dry grinding, how much of the discharged material is returned to the mill for regrinding and how can this be regulated?

What is the most economical equipment as to quality and cost per ton (or ton per hour), for intermediate grinding and why? Give the facts and figures.

To what extent does character of feldspar rock affect such considerations as the foregoing, what are these characteristics and in what manner and degree are they effective?

What are the significant factors causing the variation in production in the following citation from a letter from Joseph P. Rodgers?

"A very considerable difference in the fineness of feldspars is due to the character of rock ground. Our Hardinge mill (grinding wet) will produce forty-five hundred pounds per hour when we are working on the product of a certain quarry but it will not produce in excess of thirty-five hundred pounds per hour when grinding the product of another quarry. When an average quality of rock is being crushed, our production is two tons per hour. Tests of this material made yesterday (May 25, 1922) disclosed the fact that 61.5% of it will pass 180-mesh brass cloth, using the wet test, 66% will pass 120-mesh cloth and 95.5% will pass 40-mesh. All of the material taken from the mill passes through an 18-mesh screen.

By N. W. Stern (San Francisco):[1]—In the first place, I want you to

[1] May 24, 1922.

realize that I am in a different position from the millers in this country. We are potters and own our own feldspar deposit and do our own grinding. We have an enormous deposit and use great care in the grinding of our materials.

Mr. Kiliani of the Hardinge Co. came to this coast and interested me in a Hardinge mill. He guaranteed a certain capacity and certain fineness. On the strength of his guarantee, I ordered the mill. I followed his instructions implicitly, making all the changes he suggested at various times. All of these resulted in naught. The mill now reclines on the junk pile.

Our present flow sheet is a very simple one. We put the rock on a crusher of the old chaser type with six-foot stone and with twenty-inch space. From here it is conveyed to the Emeric separator. The fines are removed and the coarse goes into a 5 × 22 tube mill lines with Silex. The discharge of this mill goes on to the same conveyor that comes from the chaser. In this way we avoid iron and have but the one hauling, that is, putting it on to the chaser. Before we erected this plant we had a chaser, a screen and a 6 × 10 Patterson type batch mill, which gave us nine to ten tons of material a day, which, up to that time, was sufficient to keep us operating. This worked admirably but the cost of operation was a little higher than on our present scheme.

Mr. Ladoo has, in my opinion, made a serious mistake in recommending the Hardinge mill for dry grinding. This mill is used in ore dressing and is, as I understand it, a great success when grinding wet, but for dry grinding it is an absolute failure and I should think Mr. Ladoo would go into this matter more thoroughly with the people who have attempted to use this mill for dry grinding, before recommending it for this method.

Since we are grinding feldspar only for our own use, our grinding practice differs somewhat from that which it otherwise would be. We have had no trouble with mica as all our feldspar is used in the pottery where the mica is removed on the lawn. As a matter of fact most of the mica comes out in fairly large pieces at a separator as it comes from the chaser, thus it is not ground to a fine powder. Such as is reduced to fine powder is for the large part removed when the body mix is lawned in the pottery.

We have absolutely no iron in our feldspar as the only thing that touches our material is the chaser stone and the Silex lining of the tube mill.

I agree with Mr. Ladoo in that the millers have been grinding a very inferior grade of feldspar due to the fact that the accessible quarries have previously been picked of all good feldspar and today the feldspar that the potters receive is a very undependable grade. That is the main reason that we have purchased our own deposit and are doing our own grinding.

A few dollars a ton on feldspar is very insignificant compared to the quality of merchandise in which it is to be used.

The potters have often said that the beginning of winter is the best time to lay in a stock of feldspar as the mills are all piled with feldspar during the summer and they select the best feldspar first, leaving the inferior grade to grind later in the winter, so that just before the quarries open you get nothing but the cull.

BY R. B. LADOO:[1]—In my discussions previously submitted, I have expressly stated and repeated in several places that the flow sheet suggested was a composite of various machines and methods in actual use in feldspar mills today.

Even if no mills of this type were now used by feldspar companies their success, under almost identical conditions in other industries, would justify a trial by feldspar companies. Innovations always require a period of experiment, trial and adjustment, and my flow sheet was offered as a basis for experiment derived from the successful experiences of other companies.

I am aware that Hardinge mills have been tried unsuccessfully in the past by several feldspar companies. As I have already pointed out in a previous communication, the Hardinge mill was designed for the wet grinding of metallic ores and until recent years the problem of dry grinding of non-metallic minerals was given little attention. Mills designed for wet grinding were tried unsuccessfully for dry grinding. More recently, the company's attention has been given to the problems of dry grinding and changes have been made in the Hardinge mill. For example, in some instances where a six-foot Hardinge mill would be used in wet grinding, an eight- or ten-foot mill is now recommended. Furthermore, as I have previously pointed out, some feldspars, particularly those high in quartz, may not be as well adapted to this type of mill.

It should be noted that the success or failure of any method of continuous dry grinding of feldspar is dependent upon the development and use of a suitable method of sizing the milled product and returning the oversize for regrinding. This is true whether the mill used is the Hardinge, the Marcy, the Allis-Chalmers, or any other type of either short or long continuous pebble mills.

At present the best method of fine sizing seems to be by the use of some form of air separation, of which there are a number of types. Air separation has been used for many years. The problem of fine sizing is not peculiar to the feldspar industry, but the identical problem is found in the grinding and sizing of many other non-metallic mineral products. The loss of fine materials by floating off in the air to which you have referred

[1] May 24, 1922.

can be reduced to a minimum by the use of tight housings, as has been done in similar installations in other industries.

In my flow sheet I made no provision for hand-sorting prior to intermediate grinding, as I had previously outlined in my paper a method of crushing and hand sorting to be used either at the mine or at the mill. The place to do hand-sorting is preferably at the mine, so as not to incur the expense of hauling waste material to the mill.

I would again call your attention to the fact that I have proposed no system which is radically different from any now in use, but I have merely suggested as a basis for experiment a composite flow sheet made up from parts of mills found most successful in actual practice.

BY V. A. STOUT (Hardinge Company):[1]—I have been extremely interested in Mr. Ladoo's article on "Conditions in the Feldspar Industries" and the discussions it has called forth. My interest comes naturally from a close association and study of the industry, as the representative of a company selling a continuous grinding machine which has been more or less successfully introduced into that industry and which Mr. Ladoo was kind enough to mention favorably. However, it is not from the viewpoint of a representative of the company selling that mill that I wish to enter this discussion, but rather as an engineer, who has made a careful study of its grinding problems.

There are too many questions involved to warrant my doing anything more than touch them briefly. I shall, however, give some little space, if I may be permitted, to the so-called closed circuit system of grinding, the character of the product produced, and the economies of its operation. I feel that Mr. Ladoo's criticisms of mining methods have been rather well covered by previous discussions.

Mr. Rodgers in his discussion on the milling end suggested one difficulty about this so-called new process, which I think needs answering before I get into the main body of my discussion. He stated that some potters refused to buy feldspar which has been crushed in a crusher, of course, because of the iron contamination. Two methods are possible to meet this difficulty. One is by means of a magnetic pulley following the jaw crusher to take out the iron introduced into the feldspar when crushing it. This is, perhaps, the surest way but it is somewhat complicated and might be objected to as being an added expense. The second way is not so sure, but it has proven successful in actual operation. This is the use of the highest quality manganese steel for the jaws of the crusher. One company using the system described in Mr. Ladoo's article with manganese steel jaws on the crusher have been able to sell their feldspar on the potter's own test at a top price in the market.

[1] May 26, 1922.

And now as to the quality of the feldspar produced by this system. Quality must be judged from the viewpoint of marketability and that means the potter's specifications. These cover freedom from iron contamination and fineness. In the system described there is an absolute and positive control of the fineness. Either the Hummer Screens or the Emerick Air Separator are easy of adjustment and positive of their control of fineness. These machines are working today in connection with Hardinge Mills to produce feldspar which is being sold to the ceramic trade. There is no oversize on 140-mesh in the product of these machines and who among the grinders of feldspar can say that he never has had trouble with oversize in his product even after it had been ground the customary length of time in batch tube mills.

We have already discussed the question of iron contamination from the crusher. There can be no iron contamination from the Hardinge Mills which are lined with Silex, and use Danish flint pebbles as grinding mediums. Careful and exhaustive tests show that neither the Hummer screen nor the Emerick Air Separator will contaminate the finished product with iron. Since the results of these tests have been checked by the actual operation of commercial plants selling ground feldspar to the ceramic trade, we can rest assured that no iron contamination can harm the marketability of the product.

Having assured ourselves that the product of this closed circuit system of grinding is right and that it is marketable, let us examine the economies of operation of this system when compared to the practice of intermittent or batch grinding preceded by chaser mills for the preliminary breakdown. Without betraying a trust by mentioning any names, we can give below an actual comparison of costs between the two systems.

The following figures give in detail the costs of the continuous system of closed circuit grinding in Hardinge mills with control of the finished product by means of air separation just as outlined in Mr. Ladoo's article based on a capacity of 3 tons per hour of feldspar ground through 140-mesh, 98½% through 200-mesh.

POWER

	H.P.
1—No. 4 Jaw Crusher (preliminary break)	20
1—Elevator	3
1—10″ x 16″ Crusher (finished crush—through ¾″ ring)	15
1—16″ Belt Conveyor (crushed feldspar to bins)	2
1—Elevator (first Hardinge mill to screens)	1
1—8′ x 36″ Hardinge Conical Pebble Mill	50
1—8′ Hummer Separator (preliminary grind through 30-mesh)	2
1—12″ Belt Conveyor (to secondary bin ahead of finishing mill)	1
1—8′ x 48″ Hardinge Conical Pebble Mill	75
1—12″ Belt Conveyor (finished bins to cars)	1

1—Elevator (to air separator)	1
1—14′ Emerick Air Separator (to control finished product)	20
Transmission Loss	2
	193

193 H.P. hours at $1^1/_2$ c per H.P. hours divided by 3 tons per hour 9.65c

REPAIRS

1. Hardinge Mills—		
(*a*) Pebble Wear 3 lbs. per ton @ $1^1/_2$c	4.5c	
(*b*) Lining Wear $^1/_2$ lb. per ton @ $2^1/_2$c	1.25c	
(*c*) Wear on Mill Parts (feeders, gears)	2.0c	
2. Hummer Separators—Screen		
Life 30-mesh separation 6 mos	0.6c	
Other Repairs	0.5c	
3. Elevator and Conveyor Repairs	10.0c	
4. Shafting, bearings, bolting, etc	3.0c	
5. Emerick Air Separator	10.0c	
6. Jaw Crushers	2.0c	
7. General Plant Maintenance	1.0c	34.85c

OIL AND GREASE

Motors or Engines	4.0c	
Crushing and Grinding Machinery	4.0c	8.0c

LABOR

5 men — 50c per hour	83.0c	
1 Engineer or Electrician — 75c per hour	25.0c	108.0c
Total Cost per Ton of Ground Feldspar	$1.6050	

Costs in plants of the intermittent type will vary with their locality which affects the items of labor and power, but we think that the figures given below may be taken as fairly representative and at least they have the power and labor costs figured on the same basis as that used above. This plant using chaser and batch tube mills with a total capacity of 60 tons finished in 24 hours had costs as follows:

Power @ $1^1/_2$c per H.P. hour	20c
Labor	120c
Repairs	160c
Oil and Grease	10c
Total Cost per Ton of Ground Feldspar	$3.10

I hear at once the cry go up from the feldspar grinders: "My costs are not that high." I am, of course, not in position to judge individual costs in individual plants scattered over the country. Perhaps it would be unfair to label the above costs of the intermittent system as "representative." However, the costs of the continuous system are given in

detail so that all may study them and compare them with their costs of grinding feldspar. The difference between the two sets of figures is so marked that even a 20% variation downward for the intermittent system of grinding would still show a big saving in favor of the continuous system. There seems little question that a feldspar meeting the specifications of fineness and freedom from iron contamination can be produced by the continuous system of grinding in Hardinge mills in closed circuit with screens and air separators at a most reasonable cost which is probably very much lower than costs of the older systems of chaser mills and batch tube mills.

By Everett Townsend:[1]—Our plant is a very small one and we have only been running it since January 1. Our pebble mills are six feet eight inches in diameter and make twenty-seven revolutions per minute. The feldspar from the chasers is put through $^1/_4$" mesh wire. The mill is run $6^1/_2$ hours. We put 3500 lbs. of feldspar to a charge and use 4700 lbs. of pebbles of a uniform size. This grinding gives us feldspar fine enough to go through 120-mesh wire lawn, with less than 1% residue. In testing this through the lawn, we mix it with water and run it through the lawn in the slop state.

Our six months observation and experience in grinding "Rock Spar," a pink (not the white variety) orthoclase feldspar, is as follows:

We have tried to contract for what we term the "Crystal Spar," which in its pure state is practically free from free silica; our classification being that we cannot see any quartz with the naked eye. Some miners say that it is permissible to have from 5% to 10% of free silica in the feldspar and still call it selected quality. The trouble is, when you contract for selected feldspar, there creeps in a lot of rock that runs too high in quartz.

An empirical test, using a sample from a grinding of the purest crystal rock, and a sample from a grinding of rock from the same mine having a content as high as 10% of quartz showed equal fusibility. Hence, for tile the writer could not observe any different results between the bodies made from the pure "Crystal Spar" and the feldspar with the 10% of free silica.

With more than 10% of quartz content, say 25% or 30%, there are a great many impurities appearing in the rock, such as tourmaline and sulphide of copper. We have not observed a great deal of tourmaline but there is in some of the mines a great deal of sulphide of copper, which is impossible to cob out. Before putting in our own mill, we had a very costly experience with ground feldspar from a rock containing a large quantity of this impurity.

[1] May 30, 1922.

We have noticed that as the vein gets poorer it runs up against "Granite" walls. We have received some quantities of this in our shipments. As I understand it, this "Granite" rock is feldspar, quartz and mica. We have had a small lot of this class of rock come in some of our carloads but, of course, have thrown it out. We have not made a special grinding of this "Granite" rock so that we do not know how it would test by itself. We are breaking all our rock feldspar up by hand before putting it under the crusher, so that we can cob out and throw away any rock that is not up to the standard we desire.

We can get the pure crystal rock, with practically no quartz showing in the rock, providing we pay the price for it. This is the class of feldspar we are now using. But the miners should get a good price for this class of feldspar, and the grinders also. There, of course, must be a market for the No. 2 grade, free from metallic impurities, or otherwise the miners would have to get a much higher price for their selected feldspar. Therefore, if the buyers want the best, they must pay the price. If they buy at a low price, they will certainly get a No. 2 grade of feldspar.

By V. A. Stout:[1]—There has been sent around to the various people interested in the discussion of Mr. Ladoo's paper on "The Grinding and Milling of Feldspar," a colloquium in which there are certain questions asked and which it would be desirable to answer, particularly on the part of the miller, and since the writer is in better position perhaps to do this than are others in the profession, he is again entering the discussion to clear up certain of these points.

The first question asked was as to the preference of water-ground feldspar, and why. This part of the colloquium I would leave to the potters, since they can answer this question better than I can. The balance of the question, however, "Can 160-mesh feldspar be produced as economically and of as good a quality by the dry as by the wet process," the answer is that it undoubtedly can. However, the main difficulty with the wet process is the drying of the material after it has been ground to pass through 160-mesh. It is a whole lot easier to drive off the surface moisture from feldspar when it is in the lump state, say one or two inches, than when it is pulverized to pass through 160-mesh. This very fine material requires an elaborate equipment for settling out the water and bringing it down to a moisture content where it can be finally dried in specially designed dryers to eliminate any iron contamination. All of which is extremely expensive and a very difficult process.

The second question is "What are the considerations, in general, for using wet or dry conical mills, tube mills or batch mills?" The main consideration should, of course, be the quality of the finished product,

[1] Received May 26, 1922.

and the cost of producing this product. That system which gives the best quality of finished feldspar, that is, with the greatest marketability, the most economically, is undoubtedly the system which would meet the universal test of desirability of milling equipment for the entire industry. Into the cost of grinding must, of course, enter the drying of material and the power consumption, which is the major expense of milling. Of secondary importance also is the labor and attendance.

The next question is "What dimensions of mills are most suitable for given purposes, and why?" This question is certainly answered by the direct statement that in other industries the batch mill, tube mill, and conical mill have all been tried out competitively, and it is the results of these tests that must control the choice of the miller who is figuring on the installation of a grinding plant.

The next question is "In a continuous or closed circuit, with wet or dry grinding, how much of the discharged material is returned to the mill for regrinding and how can this be regulated?" The answer to this question is that the more material that is returned to the mill, the more efficient will be the grinding, and it is attempted in certain industries today to crowd up this material coming back as a reject to three or four times the initial feed going to the mill. This, of course, calls for a short length of mill through which the material can be rushed with only a relatively small amount of grinding done in each passage, but ultimately by building up the process a very large capacity with a low power consumption. This is the secret of closed circuit grinding and it has been developed to its highest fame in the mining industry in wet grinding mills, where circulating load or return of oversize from the screens or classifiers amounted in one instance to thirteen times the initial feed, and in a great number of instances to five or six times the initial feed. Normally, we would say that if as much oversize is returned to the mill for regrinding as is fed to the mill, then the efficiency of the system will be fairly well established.

The next question is "What is the most economical equipment, both as to quality and cost per ton (or ton per hour), for intermediate grinding, and why? Give the facts and figures." We take this question to refer to intermediate grinding of material through 90-mesh, which is known as the No. 2 product. As a manufacturer of equipment, we do not feel it consistent with our attitude in this discussion to describe what we consider the most economical equipment for this particular type of grinding. However, we can say that the closed circuit arrangement of a large diameter, short length pebble mill, with screens, has proven very satisfactory in a great number of instances and undoubtedly shows a much lower cost per ton for the finished material, as against batch grinding, even with the relatively shorter length of grinding necessary to produce this intermediate product. Our records show that $2^1/_2$ tons per hour of feldspar

can be finished in a Hardinge mill, operating with screening equipment, to 90% through 100-mesh, for a power consumption of 50 h.p. or 20 h.p. hours per ton, one man being in attendance, and the cost for pebbles, lining and general maintenance of the entire plant not exceeding 25 cents per ton.

The next question is "To what extent does character of feldspar rock affect such considerations as the foregoing and what are these characteristics, and in what manner and degree are they effective?" Insofar as the grinding is concerned and its costs, we have not found that any variation in character of the feldspar has any material effect upon the cost of grinding.

In answer to the final question of the colloquium, which gives a quotation from a letter by Mr. Jos. P. Rodgers, in showing the variations in capacity of a Hardinge mill, wet grinding, from 4500 lbs. on a certain feldspar produced from a certain quarry, and 3500 lbs. from another quarry, there is only one answer and that is that the one feldspar is harder to grind than the other. There is, of course, bound to be a certain variation from day to day in the relative hardness of feldspar and this hardness means that more energy must be consumed in grinding it, since in a given mill you only have a given output of energy; then naturally, the capacity of that machine will vary slightly. There are unquestionably different hardnesses of feldspar which must be taken account of in grinding, but all of which can be readily solved by simple and inexpensive tests, which, in the case of the machinery manufacturer with proper knowledge, can be very carefully predicated in advance.

N. W. Stern brought up certain points, which I think must be answered. The mill to which Mr. Stern refers is a 6-ft. diameter by 48-in. length of cylinder Hardinge Patent Conical Pebble Mill, sold him in 1916. At that time we did not know as much about grinding feldspar as we know today, but even then we knew enough to recommend that this mill should be operated in conjunction with suitable separating device to control the fineness of the finished product, and that the reject from the separator should be returned to the feed end of the Hardinge mill for further grinding. This recommendation was made to Mr. Stern.

Mr. Stern stated that at the start he did not care to install these separators, but would try the mill out without them, leaving their installation until a later date. These separators were never, to my knowledge, installed and their not being installed is the fundamental reason, as far as we can determine, for the failure of this Hardinge mill, which produced in the discharge from the mill 30% to 40% coarser than the 160-mesh required by Mr. Stern. If, however, the separators had been installed, this 30% to 40% oversize would have been taken out and sent back to the mill for further regrinding, the separator being adjusted so that the

product would all have been of the desired fineness and the installation made a success.

The capacities of conical mills, in grinding feldspar, are all based upon closed circuit grinding where a fairly uniform and fine product is desired, for experience has shown that operation in this manner produces the desired results at much less cost than if operated any other way.

DISCUSSION BY HARLOWE HARDINGE:[1]—Speaking from a manufacturer's view-point, there are a number of conditions which must be met which the mill man would not foresee. Some of these conditions I will outline in this communication. First of all, there are certain business ethics involved in giving out information which has been given to us in confidence, and it is these business ethics which have caused us to withhold concrete information which we have in our files because we have agreed not to publish or send out broadcast certain very conclusive information which we have received. There is little good in giving concrete facts if you cannot show where and how these facts were obtained. In short, our hands are tied.

Many times we have tried to get certain facts released so that we could prove to some of our business acquaintances the statements which we make involving the operation of our equipment, but in almost every case we met with an emphatic refusal.

We ran up against the very unsatisfactory condition of second-hand machinery dealers getting hold of Hardinge mills, which come on the market from time to time, and selling them to companies without regard to the work they are to perform. The main burden then devolves upon the purchaser to make the mill suit his conditions and unless he knows something about operating a mill of this type, he may get into trouble (or it may be a ball mill instead of a pebble mill). Hence, every once in a while we run up against a so-called unsatisfactory mill, and upon investigation find that it is supposed to do work which we would never have recommended had we an opportunity to advise.

Often we come against the difficulty of a slightly different size of mill; for instance, we build an 8-ft. diameter by 22-in. cylinder, 8-ft. diameter by 30-in. cylinder, and 8-ft. diameter by 36-in. cylinder. There is very little difference in the lengths of these cylinders. Hence, a second-hand dealer would say that he has an 8-ft. diameter by 22-in. cylinder mill. The Hardinge Company may have recommended an 8-ft. by 30-in. mill, and there being only 8-in. difference in the cylindrical length, his mill will do just as well. As a matter of fact, an 8-in. difference in the cylindrical length sometimes means as much as 30% difference in capacity. The purchaser does not condemn the second-hand dealer but he does the Hardinge mill.

[1] June 3, 1922.

Another point—in fields like the ceramic industry, which have a tendency to great secrecy, some companies, in order to retain their secrets or steer their competitors away from methods they employ, send out derogatory reports of the equipment they use, not that they are doing anything unethical, but they will make a point that whenever their equipment is not running right up to the minute, they will take pains that the outsider hears about it but he does not hear about the other 360 days of successful operation which enables him to keep his costs below his competitor.

These conditions which we run up against are in my opinion the chief cause for the delay of the general acceptance of our mill in the ceramic industry, for we know what the mill has done, having been on the ground ourselves and having seen the mill operating under average conditions. We have checked up the costs and found them to be so much lower than the average that it is difficult for us to comprehend, until we reflect upon the conditions as mentioned above, why this system has not been generally adopted long before this.

By Harlowe Hardinge:[1]—Every plant, with which I am personally acquainted, where we are grinding feldspar, is operating dry, with the exception of a 5-ft. mill installation at the Dental Supply Co., York, Pa., where a very high grade of feldspar goes into the manufacture of false teeth and where the fineness must be regulated very carefully. Such installations as at Erwin Feldspar Co., the old installation at Clinchfield Products Co., Bedford Feldspar Co., Mount Eagle Feldspar Co., the new installation at Golding-Keene Co., and a number of other installations, are all grinding dry.

The references of where the Hardinge mill has "failed" are all on account of old methods of operation which took place a number of years ago, when we did not know as much as we do now.

Mr. Rodgers says that Mr. Ladoo exaggerated the capacity of the mill and that the most he could ever put through an 8-ft. diameter by 22-in. cylinder Hardinge mill was 4,500 pounds per hour and that the 30-in. mill has an advertised capacity of 10% greater than the 22-in. mill. Mr. Rodgers' statement in reference to the old style mill is absolutely right but he fails to take into account that the design of the Hardinge mill has been greatly improved and we have also learned more about its operation. By changing the type of feeder, and also the inlet and discharge of the Hardinge mill, we have found the capacity to be very materially increased and as we operate these mills in an entirely different way than heretofore, Mr. Ladoo's estimates are not exaggerated.

As a concrete example of what has been done within the last two years

[1] June 9, 1922.

in grinding, I will cite our installation at the plant of the Lytle Coal Co., Minersville, Pa., which is dry grinding a very hard anthracite coal. Although coal is not the same as feldspar, the general operation is very similar. The Lytle Coal Co. were casting about for a machine to grind anthracite coal to a fineness of about 90% through 200-mesh. The mills tried out previously had proved too expensive from a standpoint of upkeep. From previous operation on similar materials, even taking into account our old operation of grinding feldspar, we recommended one of our mills to do one ton per hour to a fineness of 90% through 200-mesh. Changes in the method of operation were made which increased the capacity of this mill to $2^1/_2$ tons per hour. Another design of mill, having the same diameter as the first but changed in other respects, maintained a capacity of 3.67 tons per hour average over a month's operation. Often the capacity ran well over 4 tons per hour, the product being better than 92% through 200-mesh, the mill operating in conjunction with an air separator. This is four times as much as originally estimated and as a result this company recently ordered two 7-ft. diameter by 36-in. cylinder Hardinge Ball Mills to complete their installation.

The Canada Cement Co. is grinding a cement clinker, known to be the hardest clinker in the country. They installed our large 10-ft. mill to grind approximately 17 tons per hour, but are actually averaging over 25 tons per hour.

DISCUSSION ON "DERRY FELDSPAR QUARRY"[1]

By Raymond B. Ladoo:—The feldspar deposit described by Mr. Davis seems to be unusual, both in size and in the purity of the feldspar which it contains. While it is true that, in some districts, there occurs but one large deposit of unusual merit, surrounded by other deposits smaller and less pure, this condition does not seem to prevail generally.

In several of the large feldspar producing districts of the United States a number of deposits, nearly equal in size and purity, have been worked and other deposits discovered and held in reserve which seem to give promise of equal value.

Until the market price of feldspar reaches a point which will encourage the very thorough and systematic prospecting of less accessible areas, both in the United States and Canada, the presence or absence of other large deposits of feldspar cannot be definitely proved.

By H. Ries:—I have read Mr. Davis' paper with much interest. The general region in which the Derry quarry occurs has been proven to contain some most interesting deposits of feldspar. In the famous Richardson

[1] Davis, *Jour. Amer. Ceram. Soc.*, **5**, 294 (1922).

quarry, east of Godfrey, worked for a long period, there was a differentiation similar to that described by Davis. There the quarry showed a very large mass of deep pink feldspar in the center of which was a huge horse mostly of quartz.

The Richardson feldspar emphasized a curious fact, even more forcibly than does the Derry, that the cream or bright pink of feldspar is not necessarily due to iron oxide.

THEORY OF PLASTICITY AND POSSIBLE COMMERCIAL APPLICATION

A colloquium on this topic was intended for the Annual Convention. George A. Bole delivered an opening address, the substance of which is in his paper.[1] F. P. Hall[2] presented a summary of methods for measuring plasticity. Time did not permit extending the discussion at the convention as was planned. Hence it has been continued by correspondence.

The Editor was asked to open this informal discussion which, if done editorially, would require a review of the literature and an impartial presentation of the several theories that have been advanced. This seems to be unnecessary inasmuch as references will be made as the discussion progresses. The Editor would rather enter as a free lance, without editorial restrictions, and the following discussion is written with this freedom.

DISCUSSION BY ROSS C. PURDY:—My first approach to this question of plasticity in 1904 was from a reading knowledge of the several experiments and theories reported in the literature. I accepted the very plausible theories that the "clay substance" was somewhat soluble in water and that clays contained alumina, silica and iron hydrates which would reverse back and forth from the gelatinous state (as when precipitated from solution) to dry powder. The dry powder of these hydrates was a "gel" which would adsorb enough water to again render their mass gelatinous. I had the conception that the portions of clay, which were too small to be distinguishable under an ordinary microscope, were the prime factors in rendering the mass as a whole plastic and that it was these small particles which, through some process of molecular disintegration and hydration, went into solution, thus making a gelatinous-like mass similar to freshly precipitated aluminum hydroxide. The physical phenomena of Brownian movement and of flocculation and deflocculation were thought to be evidence of ionization reactions between the salts

[1] "Mechanism of Plasticity from Colloid Standpoint," *Jour. Amer. Ceram. Soc.*, **5**, 469 (1922).

[2] "Plasticity of Clays," *Ibid.*, **5**, 355 (1922).

in solution and the products of partial disintegration of the "clay substance."

At that time we understood it clearly that, when speaking of colloids, reference was made to state of matter rather than substance, *i. e.*, the distinction between crystalloidal and colloidal state was without reference to substance, it being supposed that all substances could be produced in either state. It was not clear, however, what state or condition a substance must be in to be distinguished as colloidal or how this transformation could be effected.

The picture had at that time of colloidal condition was exemplified by the physical properties of precipitated aluminum hydroxide, silicic acid and glue as the "gel" state, and these same things by some process converted to solutes as the "sol" state, the transition from the "sol" to the "gel" state being that of gradual precipitation from solution.

Dr. Paul Rohland[1] gives these same misconceptions which we had of colloids in 1903 to 1905. If needs be, during the progress of this colloquium, I will give an exposé of Rohland's treatise to show the very far-fetched and ill-grounded conceptions that were generally held at that time.

It was with these misconceptions regarding colloids in clays that I started work with the Geological Survey of Illinois in the fall of 1905 and it was because these conceptions would not plumb with proven chemical and ceramic facts that I had to search for evidence independently of the orthodox colloid chemistry of that time.

I came early to the conclusion that one of the reasons that chemists had been lead astray, regarding colloids in clays, was the terminology used, and hence, in the discussions with Mr. Ashley,[2] I was not only making constructive criticisms of the conceptions advanced by him but also of the terminology used.

One paragraph[3] of my discussions of Mr. Ashley's paper reads as follows: "To claim that the clay particles must be wrapped about by a colloidal coating, because the clay responds in like manner in one test with colloids, is of the same order in logic as claiming the existence of an element 'phlogiston' which all chemists did prior to the discovery of oxygen by Lavoisier in 1774."

Dr. J. W. Mellor,[4] in 1921, or twelve years later, writes: "Clays have qualities which might be predicted from the known properties of matter in the colloidal state. It is, therefore, assumed that clays contain x per cent of colloidal matter possessing qualities like those possessed by the clay itself." This explanation recalls A. Baume's "saline matter" and the

[1] " The Colloidal and Crystalloidal State of Matter."

[2] *Trans. Amer. Ceram. Soc.*, **11,** 530 (1909).

[3] *Ibid.*, **11,** 586 (1909).

[4] "On the Plasticity of Clays," *Trans. Ceram. Soc.*, **21,** I, 92 (1921).

"terra pingua" of the mediaeval chemists. The plasticity of clay has been attributed to both these imaginary substances. Indeed, just as in mediaeval times, every chemical process which was not understood was explained by an assumed terra pingua or phlogiston, so now we are inclined to attribute to the colloids every quality of clay which is not understood. Nevertheless, I believe a modified colloidal hypothesis gives the best working explanation of several properties of clay, even though it must be added that we have not progressed very far in advance of the eighteenth century. Calling the same things different names is not getting along very fast.

I have never denied the existence of colloidal matter in clays.[1] I have questioned, and still question, if plasticity of clays follows from any such process as described by Ashley[2] when he says "effect of the grinding is to expose fresh surfaces of these minerals upon which the water has a hydrating effect, forming colloidal hydrates."

An idea of the length to which the reasoning without facts went at that time, can be had from the following:[3] "The difference between the normal and the preheated clays is due to coagulation, the material has become set, to use the language of the colloid investigators, and irreversible, as far as practical purposes are concerned."[4] "He explained the change produced on the basis that the organic or inorganic colloids are shriveled up and rendered either temporarily or permanently unable to take up water and assume their former jelly-like condition."

"The chief colloidal materials[5] to be considered in clays are silicic acid, aluminum and ferric hydroxides, and the organic emulsion colloids."

"In the light of colloid chemistry,[6] we may consider these minerals in contact with water as tending toward a state of equilibrium. At the point of contact there is the tendency of the mineral to go into solution; but the action is slow, hence the colloid condition has a chance to develop"—— "at the same time new mineral combinations are being formed and part of the oxides produced go into the sol state and may later become gels. Where alumina and silicic acid sols are being formed at the same time, they tend to coagulate one another to gels. Other colloid sols have a similar effect on one another"——. "The finer the grain of the clay, the more chance there is for colloidal material to form"——. "The longer the clay particles are subjected to the solvent action of water, the more colloidal material is formed."

All of these quotations (and many more of the same sort could be quoted

[1] *Trans. Amer. Ceram. Soc.*, **11,** 590 (1909).
[2] *Ibid.*, **12,** 810 (1910).
[3] Bleininger, *Ibid.*, **12,** 506 (1910).
[4] Orton, *Ibid.*, **13,** 774 (1911).
[5] Davis, *Ibid.*, **16,** 76 (1914).
[6] *Ibid.*, **16,** 79 (1914).

from the *Transactions* of this Society and from the literature) are in line with the fallacies taught by Dr. Paul Rohland in 1913 and earlier, and which are yet being advanced by some physical chemists.[1]

Definition of Sol.—Bancroft[2] says "Sufficiently finely divided particles will be kept in suspension in a liquid indefinitely by the Brownian movement, provided coalescence and the resulting agglomeration are prevented. Such a colloidal solution is called a sol."

The portions of clay suspensions which will not clear after weeks of standing are an example of coarse sols comprising discrete particles which do not coalesce, plus salts adsorbed and in true solution, and water.

Definition of Gels.—Again quoting Bancroft, "When the colloidal particles agglomerate and precipitate, the precipitate is called a gel." There is no reference in the foregoing definition of "sol" to hydration, hydrolysis or anything other than suspension. In case of clays it is a suspension of discrete particles. The only portions of a clay that approach the "sol" state are the ultra fine particles, and the only "gel" then are these fine particles agglomerated. As a matter of fact one can wash out all the fine particles produced by thorough disintegration of the clay, and the coarse particles of hydrous silicate of alumina will, as a rule, exhibit the same plasticity as when the fine particles were admixed. The fine particle portion will not be plastic, cannot be dried and rewetted or likewise worked as clay. Furthermore, the coarse particles remaining will flocculate and deflocculate with electrolytes as before. In other words, neither the plasticity nor the behavior of clays with electrolytes are dependent on or are much influenced by that portion which would come under the definition of "sol" and "gel."

The terms "sol" and "gel" have application in the physical chemistry of clays only in a far-fetched sense; they are pictorial terms and not really applicable to the whole clay mass; they give misconceptions.

Rather than "sols" and "gels" I plead for the use of the common sense and truthful terms "deflocculated" and "flocculated." They leave out of consideration the solution ideas and refer only to dispersion and precipitation of discrete clay particles without any hydration, hydrolysis, coalescence or other physical chemical alterations in composition.

Clays do not form typical colloidal solutions; only a small portion of any clay roughly approximates such and really is not essential to plasticity. If "sol" and "gel" are not applicable to the discrete particles which will not stay in suspension but will nevertheless flocculate and deflocculate, why use such foreign language?

[1] Moore, Fry and Middleton, *Jour. Ind. Eng. Chem.*, **13,** 527 (1921); Harry N. Holmes, "Laboratory Manual of Colloid Chemistry," 104 pp. (1922).

[2] W. D. Bancroft, "Applied Colloid Chemistry," 161 (1921).

Here are two sentences,[1] "Clays can be obtained so finely divided that they can make true colloidal solutions. Colloidal clay belongs to the class known as 'suspensoids' and is reversible, that is, the particles can be dispersed in water or thrown out of colloidal solution by means of suitable electrolytes."

Within the extreme meanings of these words, no question can be raised as to their accuracy. A small portion of plastic clay can be obtained that approaches "true colloidal" solution but the only clay (Bentonite) in which a predominating proportion approaches anywhere near the true colloidal solution *state* has low bonding strength and does not add to the plasticity or bonding strength of any clay or ceramic mixture. It has adhesiveness but lacks cohesiveness. Any or all portions of any clay, the coarser grains of which are high in "clay substance" (as determined chemically), will be about as plastic and have about as high strength as the clay had before removal of the portions that approach "true colloidal solution."

The clause quoted from Schurecht reading "the particles can be dispersed in water or thrown out of colloidal solution by means of suitable electrolytes" is true in reference to such colloids as ferric hydroxide, which can be had in all stages from clear solution to gelatinous mass, but in reference to coagulation of suspended discrete particles of clay of sizes too large to be classed as colloidal, this clause gives an exaggerated picture of the case, and gives emphasis to the portion of clay which is non-essential to plasticity.

Accuracy in science is essential and so scientific statements must be, not only as to wording but also in possible interpretation by those for whom the statements are written. It seems to me nonsensical to use terms that are only approximately true in reference to the smaller portion of the clay and that too to the portion which is non-essential to the development of plasticity. It certainly gives a wholly incorrect vision of clay to say "clays can be obtained so finely divided that they can make true solutions."

It certainly does not plumb with the whole truth to say that "colloidal clay belongs to the class known as suspensoids and is reversible," for the portions not classed by size of their particles as colloidal are also reversible in the sense that they can be flocculated and deflocculated. Then too most of the fine particles that are correctly styled as colloid are at the coarse end of the colloid scale.

I grant today, as I did in 1910, that the fine clay particles come under the classification of colloid, but since the size of particles in clays are discrete and do not coalesce, and since the majority of them in most plastic clays are too large to be styled colloidal, why not characterize them as

[1] H. G. Schurecht, "The Use of Electrolytes in the Purification and Preparation of Clays," Bur. Mines, *Technical Paper* **281,** 1922.

particles (which they all are), rather than as colloids. Why give the whole collection of particles, comprising the clay, the characterization of the minor portion, especially when the colloidal portion are particles of the same sort as those of the major portion of the clay.

Since we strive to have the language we use convey most exactly our conceptions, I propose the following substitution of words when discussing clays: (1) deflocculated for sol; (2) flocculated for gel; (3) clay suspension for colloidal solution; and (4) deflocculated for dispersed.

"Set Gels."—What in clays can be styled "set gels?" Does this refer to dehydrated clay particles? If so, why the use of the words "set gels?" When clay is subjected to increasing heat treatment, the water and volatile gases are driven off, making more than a change in *state;* it is a change in substance and the dehydrated clay particles dehydrated are not of the same substance they have been. This is not a case of "set gel."

Colloids in Clays.—The colloids in clay effecting plasticity are discrete particles of hydrous silicate of alumina some of which are bundled together into coarser particles that resist disintegration by water. When a clay is made up of various sizes of "particles," the coarser ones of which are cemented agglomerates of small particles, the mass as a whole will exhibit that which we call plasticity. The larger bundles of particles will have the same adsorptive power per surface exposed and react physically with electrolytes to the same degree as will the small discrete particles. Hydration and hydrolysis of the clay substance breaking down into hydrates of alumina and silica are not necessary to an explanation of flocculation and deflocculation.

Cause of Plasticity.—In general my ideas are as stated in 1909.[1]

"Plasticity is the result of purely physical conditions and properties—adsorption, solution, molecular attraction and high surface tension." These cause the particle when wetted to hold a water saturated film. For the mass to exhibit plasticity, the particles must not be separated one from the other beyond the range of molecular attraction, one with the other, which range is sufficient to permit each to retain its maximum water envelope. Experiments have shown that the volume of water required to render a clay mass plastic is equal to the volume of water required to fill the pores when the formed mass has been dried, plus the water required to give each and all particles (or bundles of particles) its maximum water film. This salt solution film is the "slippery medium" and when the mass is dried these salt coatings are the cementing agents and when subjected to heat treatment they are the sintering media. Flocculation and deflocculation occur in response to relative difference in surface tension of the excess water, *i. e.*, water in excess of the total re-

[1] *Trans. Amer. Ceram. Soc.*, **11**, 588 (1909).

quired to render the mass plastic, and the surface tension of the water film. I called this a difference in potential, and my conception is that clay particles flocculate when the potential of the water envelopes is less than that of the excess water and they deflocculate when the potential of the water envelopes is greater. The greater surface tension of water envelope not only results in deflocculation but also requires less excess water to give the clay mass the same degree of plasticity. When the mass is in sufficient amount of water to allow free movement of particles, a condition known as "slip," the particles will flocculate as the surface tension of the excess water is increased. This explains why a small portion of salt deflocculates (it all goes to the films by adsorption) and excess of this amount of salt again flocculates.

I have given a colloid theory of plasticity in terms that describe exactly what happens. My explanation of the cause of "happenings" may contain some errors but the terms used mean just that and only that which I intend. They are not misleading.

NOTE ON THE RELATION OF THE STRUCTURE OF CLAY GRAINS TO THE PLASTICITY OF CLAYS

By H. G. Schurecht

It is undoubtedly true that the fine-grained kaolinite aggregates, or "bundles" of clay particles as Mr. Purdy calls them, exert an important influence on the plasticity of clays. It has been shown by microscopic examination[1] that most clays consist of aggregates of fine-grained kaolinite particles rather than coarse individual ones. The proportion of the clay which is readily deflocculated does not represent all of the extremely fine clay particles, since a certain portion is usually present in certain aggregates which are not affected by electrolytes.

The writer found that by agitating many clay slips, in which the clay grains were composed of fine-grained kaolinite aggregates which were not affected by electrolytes, for different periods of time, they became finer-grained upon increasing the time of shaking. With some clays a maximum degree of fineness is not obtained after continued shaking for three days. Since these aggregates may be disintegrated by agitation, it is evident that they are only loosely cemented together. Such grains impart plasticity to clays, while the firmly cemented aggregates found in flint clays which do not disintegrate by agitation in water do not impart plasticity to clays. All other things being equal, clays consisting mostly of loosely cemented aggregates of fine-grained kaolinite are more plastic than those composed of coarse crystalline kaolinite particles or firmly cemented aggregates of

[1] "The Microscopic Examination of the Mineral Constituents of some American Clays," *Jour. Amer. Ceram. Soc.*, **5**, 6–7 (1921).

fine-grained kaolinite. The presence of these loosely cemented aggregates of fine-grained kaolinite also explains why some of the clays still have considerable plasticity after the fine suspended clay is removed, while others like the Spruce Pine, N. C., kaolin, which is composed almost entirely of coarse crystalline kaolinite particles, have very little plasticity after the fine suspended material is removed.

In addition to the cemented aggregates of fine-grained kaolinite, clays also contain flocculated aggregates of fine-grained kaolinite which exert an important influence on the plasticity of clays. The writer has shown[1] that by adding 1–2 per cent alkali to plastic clays, their plasticity is greatly decreased, due to deflocculation, and their dry strength increased, while acids function oppositely. All other things being equal, those clays having the largest proportion of flocculated fine-grained kaolinite aggregates are more plastic than those having larger proportions of deflocculated clay particles and *vice versa*. By flocculated clay particles the writer means those which are capable of being readily deflocculated by the addition of alkalies.

The writer found[2] that it is possible to deflocculate a larger percentage of the extremely fine kaolinite particles, *i. e.*, below 0.0001 mm., which are considered colloidal, from ball clays than from kaolins. This would indicate that the flocculated aggregates of fine-grained kaolinite particles in the ball clays are composed of finer-grained kaolinite particles than those in the kaolin. It is, therefore, probable that the greater plasticity of ball clays as compared with kaolins is partly due to the fact that the flocculated aggregates in ball clays are composed of finer-grained kaolinite particles than those in kaolins.

It was also found that the properties of ball clays are changed much more by the addition of electrolytes than are the properties of kaolins. For example,[3] the writer found that by adding 1.5 per cent NaOH to a ball clay in the plastic state, its dry strength was increased about 400 pounds per square inch, while the dry strength of Georgia kaolin could be increased only about 75 pounds per square inch by this treatment.

Mr. Purdy states in the opening discussion that by speaking of the colloidal clay particles[4] the writer referred to that portion of clay which is non-essential to plasticity. Since the writer has found that the plasticity of many clays is affected by the initial alkalinity or acidity of the clays and since those clays having the larger proportion of extremely fine-grained

[1] "The Use of Electrolytes in the Purification and Preparation of Clays," U. S. Bureau of Mines, *Tech. Paper* **281,** 28–29 (1921).

[2] "Sedimentation as a Means of Classifying Fine Clay Particles," *Jour. Amer. Ceram. Soc.*, **4,** 818 (1921).

[3] U. S. Bureau of Mines, *Tech. Paper* **281,** 28–29 (1921).

[4] *Ibid.*, **281,** 5 (1921).

kaolinite particles are more affected by electrolytes than those composed of coarser individual particles, it seems that the fine particles in clay do play an important part in the plasticity of many clays, although it is not the only factor influencing plasticity.

The fineness of grain of the particles in the loosely cemented aggregates of fine-grained kaolinite in clays is also important and undoubtedly has an important influence on the plasticity.

In summarizing, the writer wishes to suggest the following factors which influence the plasticity of clays. It is assumed in the following that all other things are equal except the two factors cited in each case.

1. Clays composed of loosely cemented aggregates of fine-grained kaolinite are more plastic than those containing firmly cemented aggregates of kaolinite particles (*i. e.*, aggregates not disintegrated by agitation with water).

2. Clays composed of loosely cemented aggregates offine-grained kaolinite are more plastic than those composed of coarse crystalline kaolinite particles.

3. Clays composed of flocculated aggregates of fine-grained kaolinite are more plastic than those composed of deflocculated particles of kaolinite.

4. Clays consisting of aggregates which are composed of extremely fine-grained kaolinite particles are more plastic than those in which the aggregates are composed of coarser kaolinite particles.

5. Clays composed of flocculated aggregates of fine-grained kaolinite are more plastic than those composed of cemented aggregates of fine-grained kaolinite.

In the above comparison the writer has selected the extreme cases in which only two factors vary to simplify the comparison, while as a matter of fact, all of these factors may exert their influence on most clays in different degrees, hence causing the widely different properties of clays in their plastic state.

In conclusion, the writer wishes to state that the above statements are not positive conclusions, but merely opinions based upon a limited amount of laboratory work, under which condition the writer was asked by Mr. Purdy to discuss this subject.

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DISCUSSIONS ON "NEW DEVELOPMENTS IN OXY-CHLORIDE STUCCO AND FLOORING"[1]

By MAX Y. SEATON:—The paper on "New Developments in Oxy-Chloride Stucco and Flooring," by Shaw and Bole, is unquestionably of interest to the chloride industries, for it deals with investigations on the

[1] Shaw and Bole, *Jour. Amer. Ceram. Soc.*, **5**, 311 (1922).

two basic raw materials employed in the manufacture of products having a value of between ten and fifteen million dollars yearly. It appears to the writer, however, that the paper is to some extent misleading in presentation. The authors premise that the two main defects in the current oxy-chloride practice are high cost and poor quality of the products, and present certain data on methods and materials which are expected to remedy these conditions; yet on the basis of their own figures no cost reduction will result from one of their proposals, while the other, although of a more promising nature, when considered in the light of past investigations and of recent practice does not offer any immediate hope for either cost reduction or quality improvement.

These authors first propose that calcium chloride be used to replace magnesium chloride in oxy-chloride cements. Study of the table submitted shows that when calcium chloride is used, attractive strengths are only obtained in neat mixes or in mixes far higher in magnesium oxide content than those used in the field. Neat oxy-chloride cement is never used in practice, and the fact that a calcined magnesite mixed with calcium chloride sets firm and hard while a similar neat cement using magnesium chloride is not as attractive physically is without meaning from a practical standpoint. The increase in magnesium oxide, required in all of the calcium chloride cements described, far more than offsets any cost saving brought about by substitution of calcium for magnesium chloride.

The second proposal, that magnesite be replaced by dolomite in oxy-chloride cements, is of somewhat more interest. This subject has, in fact, engaged the attention of investigators for many years. Patents to Clark[1] in 1881, to Billwiller[2] in 1915 and to Mitchell[3] in 1918 show the trend of thought in this direction. The decomposition of dolomite on heating and the development of free lime have been followed by various investigators, notably by Kallauner,[4] while the quantitative effect of free or active lime on the properties of oxy-chloride are discussed quite fully in a previous paper by the writer.[5] The patents above particularly refer to the regulated burning of dolomite, but other methods for the recovery of its magnesium oxide content have had much attention. The separation of magnesium from calcium in burned dolomite rocks is, of course, common practice in the insulating magnesia industry, and is carried on also in the commercial manufacture of magnesium chloride. More recently Schurecht[6] and Eyoub[7]

[1] Brit. Pat. 1720 (1881).
[2] U. S. Pat. 1129060 (1915).
[3] U. S. Pat. 1273110 (1918).
[4] *Chem. Ztg.*, **37,** 1317 (1913).
[5] *Chem. and Met. Eng.*, **25,** 270.
[6] *Jour. Amer. Ceram. Soc.*, **4,** 558 (1921).
[7] *Eng. & Min. Jour.*, **112,** 619 (1921).

have studied the leaching out of lime by water from burned dolomite. All these methods are intended to give a product eventually suitable for use in the oxy-chloride industries.

Shaw and Bole mention a special method of preparing dolomite by which the occurrence of free lime is avoided, but give no details of process and no intimation as to probable cost. Laboratory preparations of specially treated dolomites using at least three different methods have been extensively studied under the writer's direction, but although all such methods produce a product of fair quality, the production cost outlook is by no means clear. The future of commercial production of dolomite for the oxy-chloride industries must depend on the economies of the process and of the transportation situation, for it must not be overlooked that a burned dolomite carries two parts of inert filler to one part of magnesium oxide and must be freighted to point of consumption. A cheap and satisfactory filler is usually available locally to an oxy-chloride manufacturer.

Messrs. Shaw and Bole's remarks on the tests of their prepared dolomites made by the Dow Chemical Company, although unquestionably correct when these tests were made in 1920, cannot be applied today to commercial magnesite production. In water resistance tests a 50% recovery is not considered passable today. The plant specifications of one producer[1] require in fact a recovery of 100%, a value which neither of the dolomite products reported approach.

Oxy-chloride cement failure, traceable to faulty magnesite, has unquestionably often occurred in the past, but modern methods in calcining practice have eliminated the majority of such difficulties. A failure of oxy-chloride products in the field may be due to faulty ingredients, faulty proportions or faulty workmanship. Only when great attention is given to each factor is success assured. The principles of aggregate proportioning in oxy-chloride cements are but little understood, and failure frequently results from the use of improper mixtures even when all the ingredients used in the mix are of satisfactory quality.

By Robt. D. Pike:—In discussing Messrs. Shaw and Bole's paper my remarks will be based largely upon some experimental work with which I have been connected. Although this work was principally concerned with magnesite we did some work with a dolomite from Owens Lake, California, having the following analysis:

Insol	0.55
Fe_2O_3	.00
Al_2O_3	.15
CaO	30.40
MgO	22.60
Ig. Loss	46.04

[1] The Sierra Magnesite Company, Porterville, California.

We first produced a calcined product containing 17.5% water soluble lime. This material, when mixed with aggregate and gauged with $MgCl_2$ sp. gr. 1.19, was entirely worthless as a cement. We then prepared this same dolomite so that when all of the $MgCO_3$ was calcined there was present less than 1% of water soluble lime. This latter material was ground, mixed with Ottawa standard sand in the proportion of 3–5 by weight, and gauged with the same $MgCl_2$ solution. When normal consistency was reached the ratio $\frac{MgCl_2}{MgO}$ was 0.349. Incidentally this dry mix contains the same per cent of MgO as a 1–2–5 mix, made up from 85% calcined magnesite, the figures referring to the respective weight percentages of calcined magnesite, Silex, and standard sand. This mix gave a cement having the following properties:

Initial set	2.11 hrs.
Final set	3.26 hrs.
Tensile strength	24 hrs., 379 lbs. sq. in.
Tensile strength	7 days, 569 lbs. sq. in.
Tensile strength	28 days, 589 lbs. sq. in.

The test for water resistance was crude, but indicated that this property was satisfactory.

These results seem to confirm the findings of Messrs. Shaw and Bole insofar as the latter relate to cements gauged with $MgCl_2$ and it appears likely that a pound of MgO in a properly prepared dolomite will be as valuable as a pound of MgO in calcined magnesite, at least when we consider the lean mixes employed in stucco manufacture, but we cannot accept this as a final conclusion applicable to actual practice, until we have gathered a considerable additional amount of data covering not only laboratory but field tests.

We only experimented with the use of $CaCl_2$ to a limited extent, but our results were not favorable to its use. The results obtained with $CaCl_2$ by the authors of this paper are surprisingly good, but even so they do not indicate that this cheaper material will eventually replace $MgCl_2$ because it gives inferior results in all but the neat magnesite mixes, which latter are not commercially practical. The action of these mixes is puzzling and holds interest from a theoretical view-point.

One of the main conclusions of our experimental work was that the principal independent variable affecting the quality of calcined magnesites is heat treatment, the term implying a combination of the factors, temperature of calcination, temperature to which the material is raised immediately after calcination, and the time of residence of the material in the calcining furnace. Incidentally the significance of the first mentioned factor is doubtful, because calcination is an endothermic process which proceeds actively at a given temperature, and the last two factors are probably

the significant ones in determining the properties of the finished material. It has also been noted that with the purer grades of magnesite, the so-called calcining temperature, *i. e.*, the temperature observed in the calcining zone of the kiln, should be between 900° and 1000° C to give the best results, all things considered.

It occurs to me that these facts possibly bring out a serious objection to the Shaw-Bole process, in which the temperature of calcination and the heat treatment of the product must be governed by consideration of the dissociation pressure of calcium carbonate, and cannot on this account be over 700° C, using the authors' figure, whereas experience with pure magnesites containing little or no Fe_2O_3, and in this important respect comparable with the dolomite, indicates the desirability of a calcining temperature of over 900° C, which would render the dolomite worthless because of the presence of free lime.

As the authors have pointed out in the final analysis economic consideration will govern. In this connection I have developed a simple formula for showing the relative value of magnesite and dolomite based upon the assumption that the value of unit weight of MgO is the same in both.

$$C_1 = \frac{M_1F_2 - M_2F_1 + M_1C_2 - V(M_1 - M_2) - P(M_2 - M_1)}{M_2}$$

The symbols with some approximate values follow:

M_1 = proportion MgO in dolomite = 0.27.
M_2 = proportion MgO in magnesite = 0.80.
C_1 = cost producing ton of dolomite ground ready for use at plant.
C_2 = same magnesite.
F_1 = freight rate per ton on dolomite from factory to point of use.
F_2 = same for magnesite.
P = cost of packages per ton.
V = value of aggregate at consuming point.

To compare the economic value of these two materials take a hypothetical case. Suppose that—

C_2 = \$30 (California Magnesite).
F_2 = \$16
P = \$ 2
V = \$ 3
F_1 = \$ 3

Then C_1, the cost of producing dolomite to put it on a parity with California magnesite, assuming that the former must stand only \$3 per ton freight, as compared with \$16 for the latter, would be \$12.50 per ton. In short, under the assumed conditions the cost of producing the specially calcined dolomite, ground in bulk must be \$12.50 per ton to be on a parity with magnesite.

The experimental work to which I have referred was a coöperative research between United States Bureau of Mines and Northwest Magnesite Co. into the preparation and properties of caustic burned magnesia carried out during 1920–21 at the Berkeley station of the Bureau.

By G. A. Bole: We found the optimal temperature for calcining dolomite to be between 700° and 800° C at which temperature the dissociation pressure of the calcium carbonate is considerable, as pointed out by Mr. Pike, but so long as the calcination is carried out in an enclosed space the calcium carbonate will not dissociate until the temperature reaches nearly 900° C—the temperature at which the dissociation pressure reaches one atmosphere.

All of our semi-commercial (ton lots) calcinations were carried out at a temperature of 750° C and none of them showed as much as 1% free lime. This was, of course, due to the fact that the material was under an atmosphere of carbon dioxide.

The cost of calcination lay well within Mr. Pike's estimate of $12.50 per ton.

By H. G. Schurecht: In the utilization of dolomite for oxy-chloride cements, the presence of free calcium oxide seems detrimental as Bole has pointed out. The writer, under the direction of Mr. R. T. Stull, experimented with dolomite cements prepared by calcining dolomite between 770–800° C and produced an inferior cement which never did get very hard. By calcining the dolomite at a lower temperature in an atmosphere of CO_2, as Bole recommends, the formation of free lime is prevented. However, this product has approximately 71.2 per cent $CaCO_3$ which exerts no cementing action and contains only 28.8 per cent of cement.

The writer conducted experiments on dolomite cements by calcining them to 1000° C, *i. e.*, to decompose both the $CaCO_3$ and the $MgCO_3$. The CaO was then converted to $CaSO_4.xH_2O$ by treatment with $MgSO_4$-$7H_2O$. The product was then recalcined which converted the $CaSO_4.xH_2O$ into Estrich plaster and hence a cement was produced in which both a magnesia oxychloride and Estrich plaster reaction were involved.

In a second series of tests the dolomite after calcining at 1000° C was ground with kaolin calcined at 700° C in a proportion as follows: 1 mol. of Al_2O_3 $2SiO_2$ to 1 mol. of $CaMgO_2$. The free lime in this case combined with the clay to form a water resisting cement. Blast furnace slag and basic hearth slag were used in the place of calcined kaolin with good results.

These cements differ from the type described by Bole and although the experiments were not carried through to completion they appear promising since the cementing properties of the calcium is taken advantage of instead of allowing a large percentage of inert $CaCO_3$ in the cement.

DISCUSSION ON "FIRE CLAYS OF THE EASTERN COALFIELD OF KENTUCKY"[1]

By A. M. Miller:—It is an admirable presentation of the subject, summing up well the results of previous investigation, and giving additional facts brought out by the recent examination of the field by the author of the paper.

If I may be permitted to defend my own views as to the age of this flint fire clay of that region, I would present the following facts for consideration.

1. In passing northeast along the western margin of the eastern coalfield in Kentucky, the Chester series becomes thinner and the upper members of it, especially, are apt to drop out, the Pottsville then resting on lower members of the series.

2. The exposures of the fire clay along the north fork of the Licking, one of which is the Blair's Mill exposure, is southwest of the Carter County exposures. They are evidently all of the same bed despite the fact that the quality of the clay as a refractory material may differ in the two regions.

3. At one place, the Blair's Mill exposure, the clay is undoubtedly interstratified with Chester, though only a few hundred yards away it is immediately overlaid with the Pottsville conglomerate.

4. One single case of interstratification of the bed with Chester would seem to fix its age as Chester, no matter if anywhere else to the northeast it is immediately overlaid with the Pottsville. For this laying down of the Pottsville on lower and lower beds of the Chester (and indeed in the absence of the latter on lower beds of the remainder of the Mississippian) is just what is to be expected from the thinning of these upper beds of the Mississippian as the formation is traced to the northeast.

DISCUSSION ON "MICROSCOPIC STUDY OF GROUND COAT AND COVER COAT ENAMEL REACTIONS"[2]

By R. R. Danielson:—Mr. Geisinger has made a very interesting as well as a valuable contribution to the literature on enameling. He has brought out very nicely the relation of the structure of the enamel to its ability to remain intact under the compression to which ordinary steel enamels are subjected. In our study of gray ware enamels we have noted that those enamels which show blistering from an excess of salts in the dipping operation do not usually develop fish scaling although they normally do scale.

We have also found that enamels which are under great compression

[1] H. Ries, *Jour. Amer. Ceram. Soc.*, **5**, 397 (1922).

[2] E. E. Geisinger, *Ibid.*, **5**, 322–37 (1922).

because of their low coefficient of expansion as compared with that for steel, will shiver and flake off in large patches when overfired although when properly fired they develop only typical small scales. It would, therefore, seem that the shivering Mr. Geisinger describes is an exaggerated development of the fish scale which occurs in the form of the typical scale when the enamels are properly fired. Another factor which may have caused shivering in Mr. Geisinger's work is the steel which for his purpose is of comparatively heavy gauge, thus tending to place the enamel under still greater compression.

By E. P. Poste:—It is very gratifying to realize that the rather general observations, reported by the writer,[1] have stimulated a sufficient interest on the part of the author of the present paper to bring forth a much more elaborate application of the study of enamels under the microscope.

We note that the author uses the terms "shiver" and "fishscale" as referring to different types of trouble. In general, we are of the impression that the term "shiver" has been used in connection with glazes applied to earthenware or other bodies, while the word "fishscale" has been used in connection with enamels, more particularly those applied to steel, and we are quite certain that many enamelers when using the word "shiver" think of it as synonymous with "fishscaling."

Apparently the author uses the word "shivering" to refer to the flaking off of the upper coat of enamel, leaving in a very porous condition some enamel adhering to the steel.

We are not criticizing this usage of the terms but feel that the author's point of view should be thoroughly understood in considering the paper.

The observations of the writer check the statements of the author as regards the general nature of the burning of enamel. The early stages of the process involve the solution of unfused material, while in the latter stages and certainly in over-burning, certain reactions take place which give rise to the formation of bubbles. It is probable that with the average steel enamel no one point in the burning involves the entire absence of unfused material and bubbles, so that the best compromise which may be adopted as a normal burn involves the presence of small amounts of unfused material and also the presence of a relatively small amount of fine bubbles.

In general we feel that the study of chips of enamel in cross section is a very fruitful field, not only as a matter of determining the conditions existing in the enamel but the possible causes of lack of adhesion of the enamel to the metal.

[1] Poste, "Enameled Surfaces under the Microscope," *Trans. Amer. Ceram. Soc.*, **19**, 146 (1917).

ACTIVITIES OF THE SOCIETY

Atta Boy!

A fisherman on the bank of a river was asked by a passer-by, "How many have you got?" "Wa-al," he drawled, "when I gits another, I'll hev one."

The membership record this month is a multiple of this story. When we get another personal membership we shall have just *twice* as many as last month, and when we get another corporation member we shall have just *three times* as many as last month. Prolonged applause.

The Terra Cotta Tigers produced a wicked wielder of the willow this month in A. F. Hotzinger. This wonder of Chicago actually brought in seven of the eleven new Corporation Members, single-handed. His record and that made by Salisbury, with his six White Wares Corporations two months ago, stand alone. The managers confidently expect that the Enamel Eagles and the Refractories Regulars will be ace-high next.

Bowman 2nd is beginning to put something on the ball besides the cover and he has brought in two Corporation Members, while Cruikshank and Stanger each scored with one.

Personal memberships are well scattered. J. S. McDowell, Tillotson, and W. S. Williams, all of the Pittsburgh Pill Pounders, have two runs apiece. Pence, Rhead, Orton, Ross, Wilkins, Hansen, Wilson, Danielson, Van Schoick, Watts, Gibson, Sweely, Turk, Worsham, Steinhoff, and Wenning, each scored once. With those who were received at the Secretary's office direct, this makes a total of 25 personal and 11 Corporation members.

We will now rise and stretch before the seventh inning. Then, let 'er go again.

New Members Received from June 1 to July 13

ASSOCIATE

Beidler, Edward R., 32 Toronto St., Toronto, Ont., Can., Gen. Supt., Interlocking Tile Co.

Bennett, A. Lee, 6512–44th Ave., S. W., Seattle, Wash., Student, University of Washington.

Chapman, William B., 50 Church St., New York City, President, Chapman-Stein Furnace Co.

Cooley, M. B., Hickory, Ky., President, Cooley Clay Co.

Crane, Raymond E., 220 Alleghany Ave., Kittanning, Pa., Vice-Pres. & Gen. Mgr., Eljer Co., Ford City, Pa.

Davies, B. H., 3528 Paseo, Kansas City, Mo., Chemical Industrial Engineer, Dickey Clay Products Mfg. Co.

Gammon, Marshal E., 1677 E. 93rd St., Cleveland, Ohio, Representative, "Brick & Clay Record."

Hain, Veit A., 6058 Harper Ave., Chicago, Ill., District Mgr., George J. Hagan Company.

Harlow, Justin E., 155 E. Superior St., Chicago, Ill., Chief Engineer, M. H. Detrick Co.

Hartzell, John L., 1708 Kenneth Ave., Arnold, Pa., American Window Glass Co.

Insley, Herbert, U. S. Bureau of Standards, Washington, D. C.

Kelley, George L., 25th Hunting Park Ave., Philadelphia, Pa., Chemist and Metallurgist, Edward G. Budd Mfg. Co.

Kimes, Arthur W., 426 Fourth Ave., Pittsburgh, Pa., Managing Editor, "National Glass Budget."

McCann, Donald M., 437 Forest Ave., Zanesville, Ohio.
Nichols, Arthur S., 1800 Farmers Bank Bldg., Pittsburgh, Pa., Chemist, Harbison-Walker Refractories Co.
Poschadel, Leonard R., 155 Garfield Ave., Milwaukee, Wis., Mgr., Propriety China Dish Mfg. Co.
Rodgers, Joseph P., 2414 Connecticut Ave., Baltimore, Md., Manager, Feldspar Dept., Products Sales Co.
Sheerer, Mary G., Newcomb School of Art, Newcomb College, New Orleans, La., Professor of Ceramic Decoration.
Shoemaker, Charles S., Arnold, Pa., Chemist, American Window Glass Co.
Snyder, George R., 3440 Louisa St., Oakland Sta., Pittsburgh, Pa., Metallurgist, Harbison-Walker Refractories Co.
Stief, W. C., The Florentine Pottery Co., Cambridge, Ohio.
Thompson, J. E., 2507 Townsend Ave., Detroit, Mich., Enameling Dept., Detroit Stove Works.
Vail, James G., 121 South 3rd St., Philadelphia, Pa., Chemical Director, Philadelphia Quartz Co.
Weaver, Robert A., 818 Finance Bldg., Cleveland, Ohio, President, The Ferro Enamel Supply Co.
Weber, Harry W., 2763 Bergman St., Corliss Sta., Pittsburgh, Pa., Assistant Supt., Vitro Manufacturing Co.

CORPORATION

Atlantic Terra Cotta Co., 350 Madison Ave., New York City (*William H. Powell, Pres.*).
Conkling-Armstrong Terra Cotta Co., 410 Denckla Bldg., Philadelphia, Pa. (*Thomas F. Armstrong, Pres.*)
Enterprise White Clay Co., Ltd., Real Estate Trust Bldg., Philadelphia, Pa. (*H. S. Donaldson, Treas.*)
Federal Terra Cotta Co., 101 Park Ave., New York City. (*De Forest Grant, Pres.*)
Gladding McBean & Co., Crocker Bldg., San Francisco, Cal. (*Atholl McBean, Sec.*)
Heidenkamp Plate Glass Co., Springdale, Pa. (*Jos. Heidenkamp, Pres.*)
O. W. Ketcham, 125 North 18th St., Philadelphia, Pa. (*O. W. Ketcham.*)
John Maddock & Sons, Trenton, N. J. (*H. E. Maddock, Vice-Pres.*)
New York Architectural Terra Cotta Co., 401 Vernon Ave., Long Island City, N. Y. (*R. F. Dalton, Pres.*)
South Amboy Terra Cotta Co., 105 Nassau Street, New York City. (*Peter C. Olsen.*)
The Wehrle Co., Newark, Ohio. (*W. W. Wehrle.*)

Sections and Divisions

ST. LOUIS SECTION

The first social affair ever held by this Section occurred at Forest Park Highlands, on Thursday, June 29, 1922. A number of ladies were present and the occasion was a decided success.

The Section met at the Highlands at six o'clock. A number of the members took a swim in the pool, after which everyone enjoyed a chicken dinner served on the porch of the Cottage.

After dinner the Section was entertained by Dr. O'Connell, of the American Museum of Natural History. Dr. O'Connell, of the Geology Department, is taking a hike around the world. She is traveling alone and had some interesting experiences to tell us.

Following Dr. O' Connell's talk the party was taken in charge by Mr. George Thomas

of the Highlands Fire Clay Company, who proceeded to show us the mysteries and wonders of the "Hall of Laughter" and various other attractions.

Judging from the noise made by the party as they rode the Slide, the Whirling Tub, the Shaking Stairway, or sat in a chair to rest, only to leap suddenly into the air, the Hall of Laughter is well named.

After an hour of hilarity the party proceeded to the Dance Hall, where the remainder of the evening was spent among the clang of the Cow Bells and the wail of the Saxophone.

W. R. Morgan, of the Evens & Howard Fire Brick Co., has been elected secretary of the Section, in place of the present incumbent who is moving from the vicinity.

A. B. CHRISTOPHER, *Secretary.*

PITTSBURGH DISTRICT SECTION

At the June meeting of the Pittsburgh District Section the following official actions were taken:

It was voted to appoint J. W. Hepplewhite secretary of the section to fill the unexpired term of J. W. Wright. Mr. Wright is resigning because of the pressure of other duties which interfere with the proper dispatch of the work of the secretary's office.

It was voted that J. W. Hepplewhite should represent this Section on the nominating committee of the parent society.

J. W. HEPPLEWHITE, *Secretary.*

ENAMEL DIVISION

The Research Sub-Committee of the Enamel Division for the investigation of Cast Iron met at Cleveland, Ohio, May 12, 1922, and laid out a comprehensive program for an investigation of cast iron for enameling purposes, with special reference to the relation of the iron to blistering of the enamels.

The following outline gives the principal points to be considered in the investigation:

I. Raw Materials to Finished Casting:
   - A. Source and Analysis of Raw Materials.
     1. Pig Iron
     2. Scrap
     3. Coke, etc.
   - B. Molding Practice.
   - C. Melting Practice.
   - D. Analysis of Cast Iron.
     1. Chemical Composition
     2. Metallographic Examination
     3. Physical Tests.

II. General Treatment of Castings:
   - A. Annealing
   - B. Sand Blasting
   - C. Pickling
   - D. Welding
   - E. Grinding
   - F. Machining.

III. Treatment of Enamels:
   - A. Application of Enamel
   - B. Burning of Enamel

As a means of starting the work, it was suggested that the various points in the outline, on which there is already valuable information among the members of the Enamel

Division, be taken up with the Bureau of Standards by way of turning in all available information which members have bearing on the subject.

It is planned, as a preliminary part of the work, to have the interested members of the Division furnish samples of castings which develop blistering as well as specimens of suitable iron. These samples will be examined by the Bureau of Standards for chemical composition, metallographic structure, enameling properties when coated with several types of enamels, and such other properties as may seem desirable. In addition, it is desired to obtain a history of the castings, including all available information on the cupola charge, nature of the pig iron, etc., treatment of the casting previous to and in the enameling operations, and behavior in the enameling operations. This information will be furnished through a questionnaire to be submitted by the Committee.

In this manner, it is believed that valuable information will be obtained as to the type of iron best adapted to cast iron enameling, which will permit of further systematic studies. The Bureau has arranged to install an experimental cupola to do this work after the preliminary results have been compiled.

The Committee desires the coöperation of those interested in the enameling of cast iron.

R. R. DANIELSON, *Chairman*
B. B. KAHN
W. C. LINDEMANN
M. E. MANSON
H. R. MILLS
E. P. POSTE
Research Committee on Cast Iron.

NOTES AND NEWS

WHITEWARE STUDIES IN PACIFIC NORTHWEST

The United States Bureau of Mines, in coöperation with the University of Washington, will undertake an investigation of the residual kaolins and feldspars of eastern Washington and northwestern Idaho for whiteware bodies. The work to be done will follow the lines of the kaolin investigations now under way at the ceramic experiment station at Columbus, Ohio. The work will be done in the new mines laboratory of the University of Washington at Seattle.

GEORGIA CLAYS AND BAUXITES

In the course of the investigation of Georgia clays and bauxites, being conducted by the Bureau of Mines at the ceramic experiment station, Columbus, Ohio, bricks were recently made from twelve of these clays, previously calcined at 1450° C. Porosities, load tests under heat, spalling tests and slag penetration tests were run on the burned bricks, some of them proving to be of excellent quality. The more bauxite clays did not make sufficiently dense bricks to withstand the load and spalling tests.

BRICKS FROM DOLOMITE

At the ceramic experiment station, Columbus, Ohio, the Bureau of Mines has made standard sized bricks from calcined dolomite and from raw dolomite using 10 per cent of the flux Fe_2O_3, Al_2O_3, SiO_2. Calcined dolomite was found undesirable for making into bricks as the mud slakes so rapidly, and on account of enormous shrinkage during drying and burning, all samples cracked badly. Raw dolomite, together with 10 per cent flux, gives excellent promise. The bricks so burned to 1450° C were sound, of high density and have not yet shown signs of slaking when subjected to the boiling test.

Fluorspar Investigation

R. B. Ladoo, mineral technologist of the U. S. Bureau of Mines, recently spent a month in the southern Illinois and western Kentucky fluorspar field in order to complete the investigation of the fluorspar industry. The outstanding feature of the fluorspar situation is that our known reserves are very low, and unless new deposits are found, fluorspar will be very scarce and expensive within a few years. The development of possible substitutes is being considered. The object of the fluorspar investigation is the eventual preparation of a bulletin on all phases of the fluorspar situtiaon.

Meeting of the American Chemical Society

Pittsburgh will be the host of the American Chemical Society at its Annual Fall meeting, from September 4th to September 9th, inclusive. All of the divisional meetings will be held at the Carnegie Institute of Technology, while the general meetings are scheduled at Carnegie Music Hall.

An exceptional program has been outlined for the entire week, with a variety of social events for the Councilors and their wives.

By special arrangements, the Committee of the Pittsburgh Section of the A. C. S. has obtained dormitory privileges for the Councilors at Carnegie Tech. during the meeting. The men's dormitories will be opened to house 350. One of the women's dormitories has been offered for the use of Councilors' wives.

American Construction Council Organization Meeting

The American Construction Council was formally launched as a result of a two-day organization meeting held in Washington June 19 and 20. The meeting was attended by about 170 representatives of the various groups concerned with construction. Mr. Hoover opened the meeting with a characteristically pointed and illuminating address. This was followed by an instructive address by Mr. Booth of the Guaranty Trust Company of New York. One of the inspiring addresses was delivered by Mr. E. J. Mehren. Messrs. Townley and McClellan delivered brief addresses and otherwise participated in the conference. Mr. Townley stated that the Executive Board of the Federated American Engineering Societies had voted an expression of cordiality and coöperation. The key-note thought of each address was the great need for the formation of some agency that would have as its chief function the removal from the construction industry the many ills that it now possesses. The newly elected Executive Board is to meet with Mr. Roosevelt for the purpose of electing the officers of the Council. The program committee submitted the following as the lines of activity to be undertaken by the Council. These recommendations were adopted by the conference: (1) The formation of a code of ethics acceptable to the whole industry and to the public; (2) Gathering of adequate statistics from all sources; (3) Reduction of the national shortage of building trade mechanics and the establishment of the necessary apprenticeship system; (4) Coöperation in establishing uniform building codes throughout the country; (5) Coöperation with railways in expediting the revision of existing freight rates on construction materials; (6) The establishing and strengthening of local organizations throughout the country to bring about the coöperation of all elements in conformity with the principles of the Council; (7) The investigation of the evils of seasonal employment and migration of labor; (8) The encouragement of local building shows; (9) Simplification and the elimination of waste; (10) Education of the public as to the desirability of a better distribution of its construction and maintenance requirements; (11) Promotion of health and safety for workmen and the reduction of loss of life; (12) The reduction of waste of construction materials from preventable fires; (13) The study of old buildings in order to establish superior methods of construction; (14) The education of the public as to the necessity and economy of properly maintaining structures.

Research School in Australia

Those who are interested in the spread of research in ceramics throughout the world will be glad to note that a research center has been established by the Australian Commonwealth at the Brunswick Technical School. Experiments will be conducted and tests made at the Brunswick School of Pottery, and it is expected that this will encourage and hasten the development of the clay-working industry in Australia.

Who's Where in the American Ceramic Society

E. E. Ayars, of the American Refractories Co., has been changed from Danville, Ill., to Devil's Lake, Wis.

Lawrence H. Brown, formerly with the R. Thomas & Sons Co., East Liverpool, is now connected with the Edwin M. Knowles China Co., Newell, W. Va.

F. M. Burt, of the American Stamping and Enameling Co., has moved from Massillon, Ohio, to Westmoreland, W. Va.

A. B. Christopher, formerly of the Evens & Howard Fire Brick Co., and secretary of the St. Louis Local Section, has associated himself with the Southern Brick Co., Jonesboro, Ark.

Dwight T. Farnham has severed his connection with the C. E. Knoeppel Co., of which he has been vice-president, and has opened private offices as a Consulting Engineer at 347 Madison Avenue, New York City.

E. H. Fritz, of the Pittsburgh High Voltage Insulator Co., is now located at 609 Main St., Latrobe, Pa.

G. W. Rathjens has notified the office that he is no longer in St. Paul, Minn., but at 6106 Dorchester Ave., Chicago, Ill.

Charles F. Ryan, who has been with the Chapman-Stein Furnace Co., at Mt. Vernon, Ohio, is now with the Russell Engineering Co., St. Louis, Mo.

Fred H. Schwetye has resigned his position with the Laclede-Christy Clay Products Co. and has accepted the position of Secretary of the Grand View Fire Clay Co., St. Louis, Mo. Mr. Schwetye was in the employ of the former company for sixteen years and during the last four years was General Superintendent of the plants. In his new position he will be in charge of mines and plants of the Grand View Co., manufacturing special prepared clay mixtures for the glasshouse, zinc, and foundry trade, as well as high grade refractory materials.

B. B. Swinnerton has recently become connected with the Limoges China Co., at Sebring, Ohio.

E. W. Washburn, formerly director of the department of Ceramics at the University of Illinois, is at present in Europe. His permanent address is the National Research Council, Washington, D. C.

Calender of Conventions

AMERICAN CERAMIC SOCIETY, Summer Excursion Meeting—Montreal and Canadian points, August 13–19, 1922.

American Society of Sanitary Engineers—Cedar Point, Ohio, August 22–24, 1922.

Annual Safety Congress of the National Safety Council—Detroit, Mich., August 28–September 1, 1922.

American Chemical Society—Pittsburgh, Pa., September 5–9, 1922.

National Association of Brass Manufacturers—Detroit, Mich., September 6–8, 1922.

Association of Iron and Steel Electrical Engineers—Cleveland, Ohio, September 11–15, 1922.

Eighth National Exposition of Chemical Industries—New York City, September 11–16, 1922.

American Electrochemical Society—Montreal, Canada, September 21–23, 1922.

American Institute of Mining and Metallurgical Engineers—San Francisco, Cal., September 25–28, 1922.

National Association of Commercial Organization Secretaries—Chicago, Ill., October 23–25, 1922.

National Society for Vocational Education—Detroit, Mich., November 30–December 2, 1922.

Dental Manufacturers Club—St. Louis, Mo., November 20, 1922.

Dental Exhibit of the Dental Manufacturers Club—St. Louis, Mo., November 21–24, 1922.

National Exposition of Power and Mechanical Engineering—New York City, December 7–13, 1922.

Mining and Metallurgical Society of America—New York City, December 7–13, 1922.

American Malleable Castings Association—Cleveland, Ohio, January 10, 1923.

National Jewelers Board of Trade—New York City, January 18, 1923.

Canadian National Clay Products Association and Western Ontario Clay Workers Association—Hamilton, Ont., January 24–26, 1923.

American Concrete Institute—Detroit, Mich., February, 1923.

National Association Builders Board of Control—Des Moines, Iowa, February, 1923.

AMERICAN CERAMIC SOCIETY—Pittsburgh, Pa., February 12–17, 1923.

Natural Gas Association of America—Louisville, Ky., Spring 1923.

American Institute of Mining and Metallurgical Engineers—New York City, February 19–22, 1923.

National Association of Stove Manufacturers—Richmond, Va., May 9–10, 1923.

American Association of Museums—Charleston, S. C., May, 1923.

JOURNAL AMERICAN CERAMIC SOCIETY

Preparation of Abstracts

Every article in THIS JOURNAL **is to be preceded by an abstract prepared by the author and submitted by him with the manuscript.** The abstract is intended to serve as an aid to the reader by furnishing an index and brief summary or preliminary survey of the contents of the article; it should be suitable for reprinting in an abstract journal so as to make a reabstracting of the article unnecessary. The abstract should, therefore, **summarize all new information completely and precisely.** Furthermore, in order to enable a reader to tell at a glance what the article is about and to enable an efficient index of its subject matter to be readily prepared, the abstract should contain **a set of subtitles** which together form a **complete and precise** index of the information contained in the article. This requires at least one and often several subtitles even for a short abstract.

In the preparation of abstracts, authors should be guided by the following rules, which are illustrated by the abstracts in THIS JOURNAL for February and March, 1921.* The **new information** contained in an article should first be determined by a careful analysis; then the subtitles should be formulated; and finally the text should be written and checked.

Rules

1. **Material not new** need not be analyzed or described in detail; a valuable summary of a previous work, however, should be noted with a statement indicating its nature and scope.

2. **The subtitles should together include all the new information;** that is every measurement, observation, method, improvement, suggestion and theory which is presented by the author as new and of value in itself.

3. **Each subtitle should describe the corresponding information so precisely** that the chance of any investigator being misled into thinking the article contains the particular information he desires when it does not, or vice-versa, may be small Such a title as "A note on blue glass," for example, is evidently too indefinite a description of information regarding "Absorption spectra of glass containing various amounts of copper-cobalt and chromium-cobalt." General subtitles, such as "Purpose" and "Results" should not be employed as they do not help to describe the specific information given in the article.

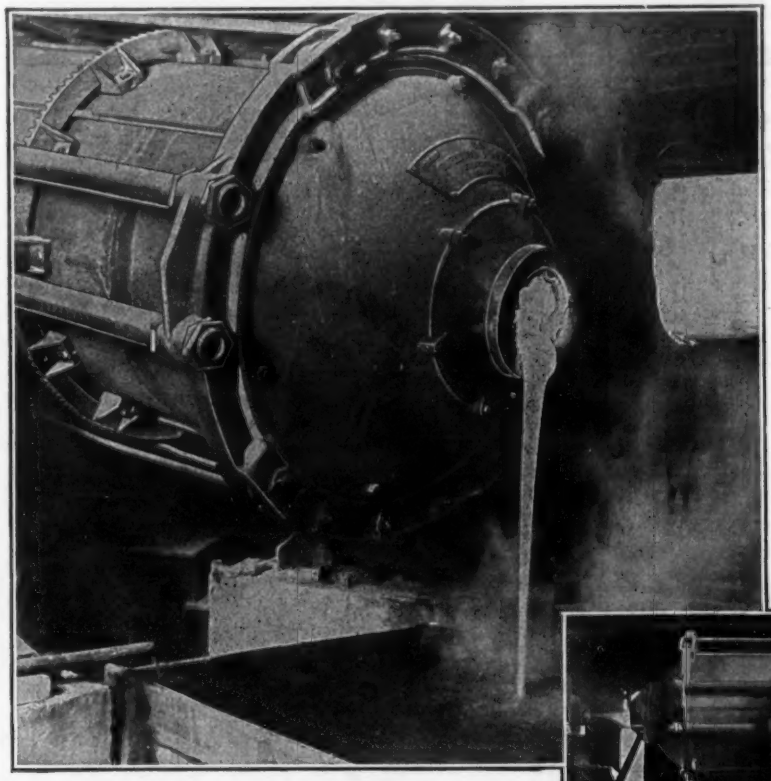
4. **The text should summarize the authors' conclusions and should transcribe numerical results of general interest,** including those that might be looked for in a table of physical and chemical constants, with an indication of the accuracy of each. It should give all the information that anyone, not a specialist in the particular field involved, might care to have in his note book.

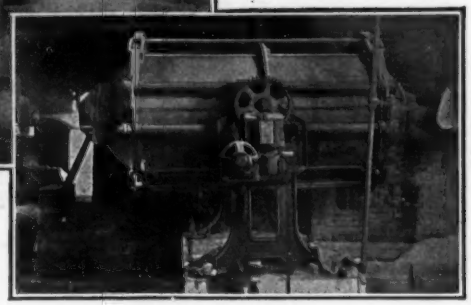
5. **The text should be divided into as many paragraphs as** there are distinct subjects concerning which information is given, but no more than necessary. All parts of subtitles may be scattered through the text but the subject of each paragraph, however short, must be indicated at the beginning.

6. **Complete sentences** should be used except in the case of subtitles. The abstract should be made as readable as the necessary brevity will permit.

7. **The** ms. of all abstracts must be typewritten and double or triple spaced.

* The rules were prepared by the Research Information Service of the National Research Council. The Society is indebted to Dr. G. S. Fulcher of the Corning Glass Works (formerly with the National Research Council) for the rules and the illustrative abstracts.





These illustrations made from photographs taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.

12-21

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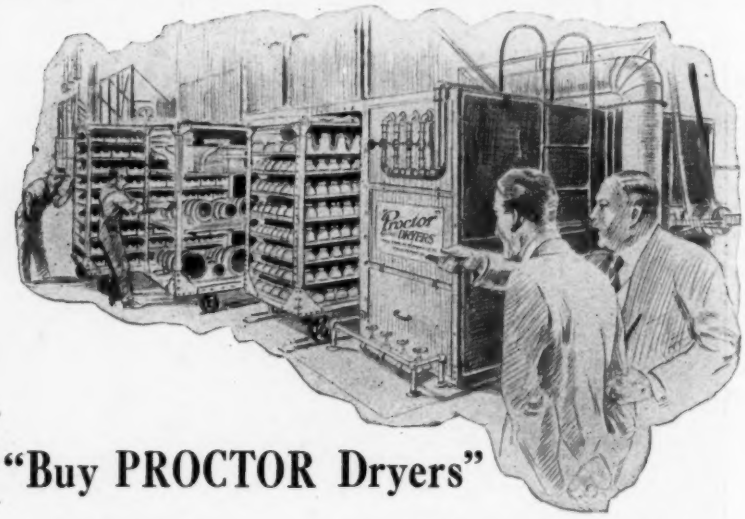

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Clay (Electrical —Porcelain)
Edgar Brothers Co.
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Old Hickory Clay & Talc Co.
Paper Makers Importing Co., (Inc.)
Clay (Enamel)
Edgar Brothers Co.
Johnson-Porter Clay Co.
Old Hickory Clay & Talc Co.
The Vitro Manufacturing Co.
Clay (Fire)
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Old Hickory Clay & Talc Co.
Paper Makers Importing Co., (Inc.)
Clay (Potters)
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Clay (Sagger)
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Johnson Porter Clay Co.
Old Hickory Clay & Talc Co.
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Hadfield-Penfield Steel Co.
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Mueller Machine Co., Inc.
Clay Miners
Edgar Brothers Co.
Johnson Porter Clay Co.
Old Hickory Clay & Talc Co.
Clay (Wall Tile)
Old Hickory Clay & Talc Co.
Clay Washing Machinery
Mueller Machine Co., Inc.
Clay Working Machinery
Hadfield-Penfield Steel Co.
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Seaboard Fuel Corp.
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Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.
Wuerz, Eugene
Conditioning Machinery
Philadelphia Drying Machinery Co.
Conical Mills
Hardinge Co.
Controllers
General Electric Co.
Conveyors (Clay, Sand, Brick, etc.)
Hadfield-Penfield Steel Co.
Philadelphia Drying Machinery Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.
Controllers (Automatic Temperatures)
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Chambers Brothers Co.
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Proctor and Schwartz, Inc.
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Drying Machinery
Philadelphia Drying Machinery Co.
Proctor and Schwartz, Inc.
Manufacturers Equipment Co.
Electrical Instruments
Charles Engelhard
Wilson-Maeulen Co.
Electrical Porcelain Machinery
Mueller Machine Co., Inc.
Enameling Formulas
Wuerz, Eugene
Enameling Equipment, Complete
The Porcelain Enamel & Mfg. Co.
Enameling Furnaces
General Electric Co.
The Porcelain Enamel & Mfg. Co.
U. S. Smelting Furnace Co.
Wuerz, Eugene
Enameling Muffles
General Electric Co.
Parker-Russell Mining & Mfg. Co.
Enameling, Practical Service
The Porcelain Enamel & Mfg. Co.
Enamels, Porcelain
The Porcelain Enamel & Mfg. Co.
The Vitro Manufacturing Co.
Engineering Service
Chambers Brothers Co.
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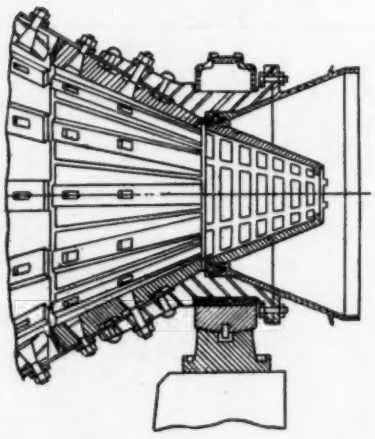

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Golding-Keene Co.
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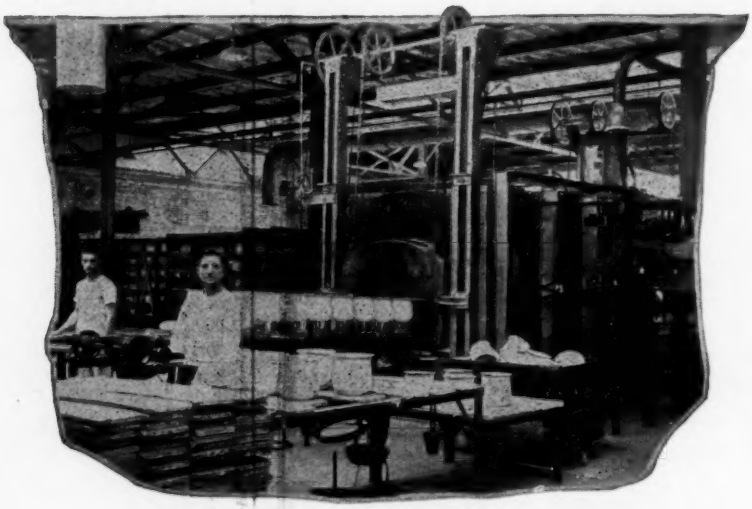

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ALPHABETICAL LIST TO ADVERTISERS

	Page
Chambers Brothers Co.	16
Drakenfeld and Co., B. F.	11
Dominion Feldspar Corporation	13
Edgar Brothers Co.	16
Engelhard, Charles Inc.	14
General Electric Co.	8
Golding-Keene Co.	12
Hadfield-Penfield Steel Co.	17
Hardinge Co.	6
Harshaw, Fuller and Goodwin Co.	2
Journal of the Society of Glass Technology	16
Johnson-Porter Clay Co.	12
Manufacturers Equipment Co.	15
Montgomery Porcelain Products Co.	17
Mueller Machine Co., Inc.	Back cover
Nashville Industrial Corporation	14
O'Brien and Fowler	12
Old Hickory Clay & Talc Co.	14
Paper Makers Importing Co., (Inc.)	15
Parker-Russell Mining & Mfg. Co.	10
Penland Feldspar & Kaolin Co.	14
Pennsylvania Pulverizing Co.	21
Pennsylvania Salt Mfg. Co.	22
Philadelphia Drying Machinery Co.	1
Porcelain Enamel & Mfg. Co.,	Inside back cover
Potters Supply Co., The	16
Proctor and Schwartz, Inc.	4
Roessler and Hasslacher Chemical Co.	Inside front cover
Russell Engineering Co.	20
Seaboard Fuel Corporation	19
Surface Combustion Co.	12
U. S. Smelting Furnace Co.	3
Vitro Manufacturing Co.	20
Wuerz, Eugene	17
Wilson-Maeulen Co., Inc.	10

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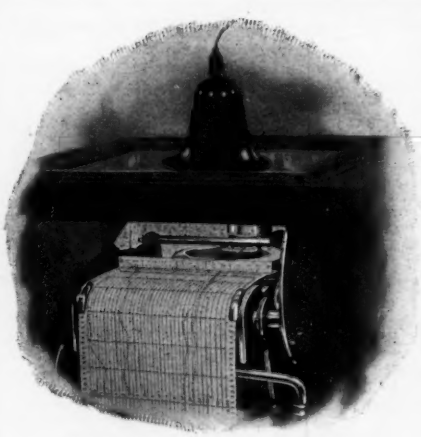

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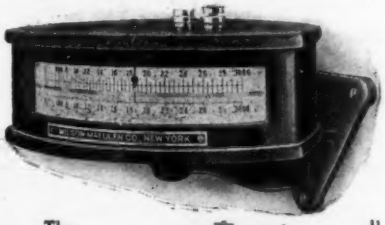

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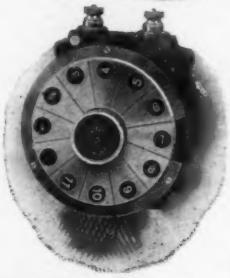

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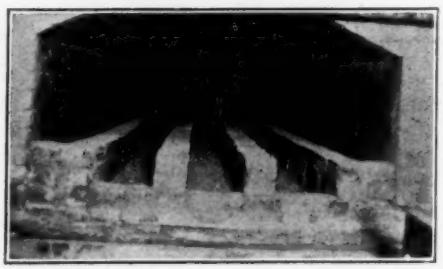

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